REPORT OF THE

DEFENSE SCIENCE BOARD

TASK FORCE

ON

DEFENSE SCIENCE AND TECHNOLOGY BASE FOR THE 21ST CENTURY

June 1998

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OFFICE OF THE UNDER SECRETARY OF DEFENSE
FOR ACQUISITION & TECHNOLOGY
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REPORT OF

THE DEFENSE SCIENCE BOARD TASK FORCE ON

DEFENSE SCIENCE AND TECHNOLOGY BASE FOR THE 21ST CENTURY

30 June 1998

OFFICE OF THE UNDER SECRETARY OF DEFENSE FOR ACQUISITION & TECHNOLOGY

WASHINGTON, D.C. 20301-3140

This report is a product of the Defense Science Board (DSB). The DSB is a Federal Advisory Committee established to provide independent advice to the Secretary of Defense. Statements, opinions, conclusions, and recommendations in this report do not necessarily represent the official position of the Department of Defense.

This report is UNCLASSIFIED.

OFFICE OF THE SECRETARY OF DEFENSE
3140 DEFENSE PENTAGON
WASHINGTON, DC 20301-3140

DEFENSE SCIENCE BOARD

AUG 26 1998

MEMORANDUM FOR UNDER SECRETARY OF DEFENSE (ACQUISITION & TECHNOLOGY)

SUBJECT: Final Report of the Defense Science Board Task Force on the Defense Science and Technology Base for the 21st Century

I am forwarding the final report of the Defense Science Board Task Force on the Defense Science and Technology (S&T) Base for the 21st Century.

This report examines issues involved in assuring that the United States has an adequate technology base to maintain military superiority into the 21st Century. The Terms of Reference directed that the Task Force make recommendations on the funding, management, and execution of a properly focused DoD technology base program served by competent scientists and engineers.

The Task Force addressed all of the specific issues in the Terms of Reference, but believes the two most salient recommendations are:

1. That the Deputy Secretary of Defense insure the future superiority of U.S. military forces by increasing the funding for the Department's Science and Technology Program to $8 billion per year.

2. That the Deputy Secretary of Defense direct the Office of the Secretary of Defense (OSD) and the Services to staff a majority of their S&T management and execution technical positions with individuals provided from the private sector under the Interagency and Personnel Act and a reinstated Public Law 313 (1947).

I endorse all of the Task Force's recommendations and propose you review the Task Force Chairman's letter and report.

Craig Fields
Chairman

OFFICE OF THE SECRETARY OF DEFENSE
3140 DEFENSE PENTAGON
WASHINGTON, DC 20301-3140

DEFENSE SCIENCE BOARD

JUN 30 1998

MEMORANDUM FOR CHAIRMAN DEFENSE SCIENCE BOARD

SUBJECT: Final Report of the Defense Science Board Task Force on the Defense Science and Technology Base for the 21st Century

Attached is the report of the Defense Science Board Task Force on the Defense Science and Technology for the 21st Century. This Study was requested by the Director of Defense Research and Engineering in the Spring of 1997. The Terms of Reference directed that the Task Force make recommendations on these issues:

- The proper funding level for the Science and Technology program
- The management of the Science and Technology Program
- The execution of the Science and Technology Program
- How DoD can be assured of a supply of competent scientists and engineers
- The technical focus of the Science and Technology Program

The Task Force Report makes recommendations of all of these issues. The Task Force believes that the most important of these recommendations are:

- That the Deputy Secretary of Defense insure the future superiority of U.S. military forces by increasing the funding for the Department's Science and Technology Program to $8 billion per year.
- That the Deputy Secretary of Defense direct the O.S.D. and the Services to staff a majority of their S&T management and execution technical positions with individuals provided from the private sector under the Interagency Personnel Act and a reinstated Public Law 313 (1947).

The Task Force believes that the implementation of these two important recommendations together with the others contained in the Report are necessary to insure the future military superiority of U.S. military forces in the 21st Century.

The Task Force would like to express it's appreciation for the extensive support provided by the O.S.D. staff, particularly Colonel Alan R. Shaffer.

I would also like to thank the other members of the Task Force for their very helpful contributions and advice.

Yours truly,

Walter E. Morrow Jr.

Walter E. Morrow Jr.

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EXECUTIVE SUMMARY

The Defense Science Board Task Force on the Defense Science and Technology Base for the 21st Century was formed in May 1997 to address issues involved in assuring that the United States has an adequate technology base to maintain military superiority into the 21st Century. Specifically, the Task Force was asked to addressed five questions:

- How much DoD science and technology (6.1, 6.2, and 6.3) is needed to maintain continued U.S. supremacy considering U.S. and global civil technology?
- What is the best process for planning and managing DoD's science and technology program including exploitation of other sources?
- What desirable changes should be made in the execution/performance of the DoD science and technology program?
- How can a continuing supply of competent engineers and scientists for DoD research and acquisition be assured?
- What new technical challenges should be addressed in the science and technology program?

The Task Force reviewed current science and technology management and execution practices within the DoD, other government agencies, and industry to draw from the best of each. In summary, the Task Force observations are:

- Past science and technology developments had a defining impact on military capabilities in the 20th Century. Current technology developments are therefore vital to future U.S. military capability and the maintenance of U.S. military dominance.
- No formula was discovered for establishing the optimum level of DoD investment in science and technology, but the most successful industries invest about 15% of sales in research and development with about 3.5% of sales invested in research (equivalent to the DoD S&T program). This would imply that, currently, DoD should invest at least $8 billion in S&T.
- DoD management of R&D involves a very complex organizational structure with conflicting lines of authority between Congress, OSD, and the Services. Successful industries on the other hand use much simpler R&D management organizations with clear lines of authority.
- OSD's portion, including DARPA, has steadily increased to 50% of the total S&T program because of Service reductions in their S&T funding and shifts of

functions to OSD and defense agencies such as BMDO. Further reductions in the Service S&T funding could seriously effect their future capabilities since the OSD programs do not address the full range of Service needs.

- DARPA enjoys the greatest S&T management success in DoD because it is project oriented, has fewer constraints in program initiation, and because of the quality of its technical managers. More than 50% of the managers are engaged for limited terms from outside the Civil-Service system.

- The DoD and Service S&T Program is executed in universities (~10%), university-affiliated research centers (~25%), industry (~45%), and Service laboratories (~20%). While S&T program execution in universities and industry is viewed as generally satisfactory, there is serious concern about the execution in many of the Service laboratories.

- The effectiveness of the technical staff of the Service laboratories is significantly impaired compared with the private sector. The impact of Civil-Service personnel regulations is to blame. The regulations prevent the laboratories from offering new employees salaries competitive with the private sector, rewarding technical staff in proportion to performance, and removing non-performing staff.

- The transfer of technology among the Nation's performers of the DoD R&D program is believed to be significantly impaired because of the wide organizational and physical dispersal of DoD S&T performers. This is in sharp contrast to the practice of most successful industrial organizations.

- An insufficient proportion of the current S&T Program is focussed on revolutionary technology offering five-to ten-fold improvements in military capabilities. While the DARPA program focuses predominantly on such improvements, the programs of the Services tend to focus more on incremental improvements.

The Task Force recommends several steps to provide an enhanced science and technology program to support continued military superiority of the United States. Specifically, the Task Force makes five major recommendations:

1. Deputy Secretary of Defense should not allow a decrease in the science and technology program (6.1, 6.2, and 6.3) and should increase it to at least $8 billion to insure continued technical superiority of U.S. military forces.

2. Under Secretary of Defense (Acquisition & Technology) and the Services should strengthen the management and relevance of the science and technology program by taking the following specific actions:

   - Strengthen DDR&E by expanding his responsibility to cover 6.1, 6.2, 6.3, 6.4 and 6.5 programs.

   - Integrate science and technology management structure in each Service, following the integrated Office of Naval Research structure using DARPA-like organizations.

   - Use DARPA for revolutionary projects while enhancing the coupling of DARPA technologies to the Services.

   - Encourage Services to focus one-third of the Service S&T programs on revolutionary programs.

   - Fill key science and technology management positions with limited-term (4-6 year), high-quality scientific personnel from the private sector (universities, non-profits, and industry). By 2002 DoD should increase to the current 3.3% of key non-DARPA S&T positions filled from the private sector 50% or more.

3. The Services should revitalize execution of S&T programs by staffing up to 50% of their scientific and engineering laboratory center positions over a five-year period with a combination of:

   - Limited-term (4-6 year) scientific and engineering personnel (IPAs) provided by the private sector (from universities, non-profits, and industry).

   - A reinstatement of the 1947 Public Law 313 for high-level S&T management positions (requires Congressional action).

4. DDR&E with the Services' support should take the lead to enhance the productivity of the Service laboratories and centers by organizational and physical consolidation.

5. DDR&E should insure that approximately one-third of the science and technology program elements are devoted to revolutionary technology initiatives. DARPA should play a major role in executing these efforts along with the Services. DDR&E should also insure that 6.4 funds are programmed by the Services to implement successful revolutionary science and technology programs.

The Task Force believes that the implementation of these recommendations will provide the Department of Defense with a more effective and responsive Science and Technology Program that will ensure a healthy science and technology base vital to the future of U.S. military superiority.

I. INTRODUCTION

The Defense Science Board was tasked in April of 1997 by Dr. Anita Jones, who was at that time Director of Defense Research and Engineering, to carry out a study of the Department's science and technology program.

A. Membership

The membership and supporting staff of the Task Force consisted of the following individuals:

Chair: Professor Walter Morrow, MIT Lincoln Laboratory

Members: Dr. John D. Christie, Logistic Management Institute
Dr. Robert S. Cooper, Atlantic Aerospace
Dr. Delores M. Etter, U of Colorado
Dr. Randy Isaac, IBM
Dr. Bob Laudise, Bell Laboratories/Lucent Tech.
Prof. Paul L. Penfield, Jr., Massachusetts Institute of Technology
Mr. Vincent Vitto, Draper Lab

Executive Secretary: Col Alan Shaffer, USAF

DSB Secretariat: LTC T. VanHorn, USA
CDR Dave Norris, USN

B. Tasking

The Task Force was asked to study the following topics:

- How much DoD S&T (6.1, 6.2, and 6.3) is needed to maintain continued U.S. military capabilities considering U.S. and global civil technology?

- What is the best process for planning and managing DoD's S&T program including exploitation of other sources?

- What desirable changes should be made in the execution/performance of the DoD S&T program?

- How can a continuing supply of competent engineers and scientists for DoD research and acquisition be assured?

- What new technical challenges should be addressed in the S&T program?

The complete tasking statement is provided as Appendix A. Note that the scope of the study was expanded by the acting DDR&E, George Singley, from consideration of only the Technology Base Program to that of the entire Science and Technology Program.

C. Briefings

The Task Force met on eight occasions to hear briefings on both industrial and governmental experiences in the management and execution of research and development. The sources of this experience include:

Industrial R&D Organizations:
IBM, Lucent, 3M, Merck, Rockwell, Dupont, Raytheon, Bell Labs/Lucent Technologies, NEC Research Institute, Lockheed Martin, SAIC, Boeing

Industrial Research Institute

OSD:
DDR&E, DARPA, BMDO, Industrial College of the Armed Forces

Service Laboratories:
Army Research Laboratory, Naval Research Laboratory, Air Force Research Laboratory

U.S. Government R&E Funding Organizations:
NSF, DOE, NASA, DIA, CIA, NSB

Foreign Military R&D:
U.K. Defense Laboratories

Representative Sampling of Service Acquisition Offices

A complete listing of the briefings is provided as Appendix B.

II. BACKGROUND

A. Twentieth Century Technology Developments and Their Impact

The 20th Century has been the occasion for a number of very significant technology innovations that have had dramatic impacts on military capabilities. Figure 1 shows selected innovations together with the approximate dates of first demonstrations and also approximately when the first impact on military operations occurred.

S&T Base DSB Task Force

Past Technology Developments Have Had a Defining Impact on Current Military Capabilities

Technology	Approximate Date of First Demonstration	Approximate Date of First Significant Military Applications
Radio	1901	1914
Airplane	1903	1916
Vacuum Tube	1906	1915
*Tank	1916	1916
Liquid-Fueled Rockets	1922	1944
*Radar	1925	1939
*Gas Turbine	1935	1944
*Digital Computer	1943	1945
*Ballistic Missile	1944	1945
*Nuclear Weapons	1945	1945
Transistor	1948	1957
*Inertial Navigation	1950	1955
*Nuclear Propulsion	1950	1960
*Artificial Earth Satellites	1957	1960
*Integrated Circuit	1960	1970
* Laser	1961	1967
*Precision Weapons	1965	1967
* AI Expert System	1965	1990
*Stealth	1970	1990
* Modern Unmanned Air Vehicle (cruise missiles)	1980	1990

*Funding by military R&D

Some additional post 1970's innovations are expected to have impact: MEMS, UltraScale Computing, etc.

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Fig. 1: History of Military Critical Technology Developments

These innovations together with others have produced very large changes in military capabilities. Figure 2 indicates some of the changes that have occurred over the past century.

S&T Base DSB Task Force

Impact of Technology on Selected Military Capabilities in the 20th Century

	Approximate Capabilities					
	1900	1925	1950	1975	2000	
Aircraft Range	-	200	2,000	4,000	8,000	Miles
Aircraft Speed	-	150	500	2,000	2,000	Miles/hr
Aircraft Payload	-	500	20,000	80,000	100,000	Pounds
Ballistic Missile Range	1	10	200	6,000	12,000	Miles
Radar Range	-	2	200	20,000	100,000	Miles
Radar Resolution	-	-	1,000	1	0.1	Feet
Navigation Precision	10	10	0.1	0.01	0.001	Miles
Radio Communication Range	-	500	3,000	10,000	10,000	Miles
Radio Communication Capacity	-	10	10,000	10^7	10^9	Bits/sec
Weapon Precision	100	100	100	10	1	Feet

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Fig. 2: Military Impact of 20th Century Technology Developments

B. Structure and Funding of the Defense Science and Technology Program

The current DoD Research, Development, Test and Evaluation Program is managed under a number of budget categories totaling about $36 billion in FY98. The following tabulation indicates the names, budget categories, and funding of each of the categories:

	BUDGET CATEGORY	TITLE	FUNDING	
S	6.1	Basic Research	$ 1.2 billion	
&	6.2	Applied Research	$ 2.8 billion	$7.4 B
T	6.3	Advanced Technology Development	$ 3.4 billion	
	6.4	Demonstration & Validation	$ 5.6 billion	
	6.5	Engineering & Manufacturing Development	$ 8.5 billion	
	6.6	RDT&E Management Support	$ 3.1 billion	
	6.7	Operational Systems Development	$11.3 billion	
		TOTAL	$35.9 billion	

This study is concerned only with the top three categories which total in funding about $7.4 billion in the FY98 DoD budget.

The funding history of the DoD S&T program has fluctuated significantly over the past quarter century. A plot of the DoD S&T funding in 1997 constant dollars over this time period is shown in Figure 3.

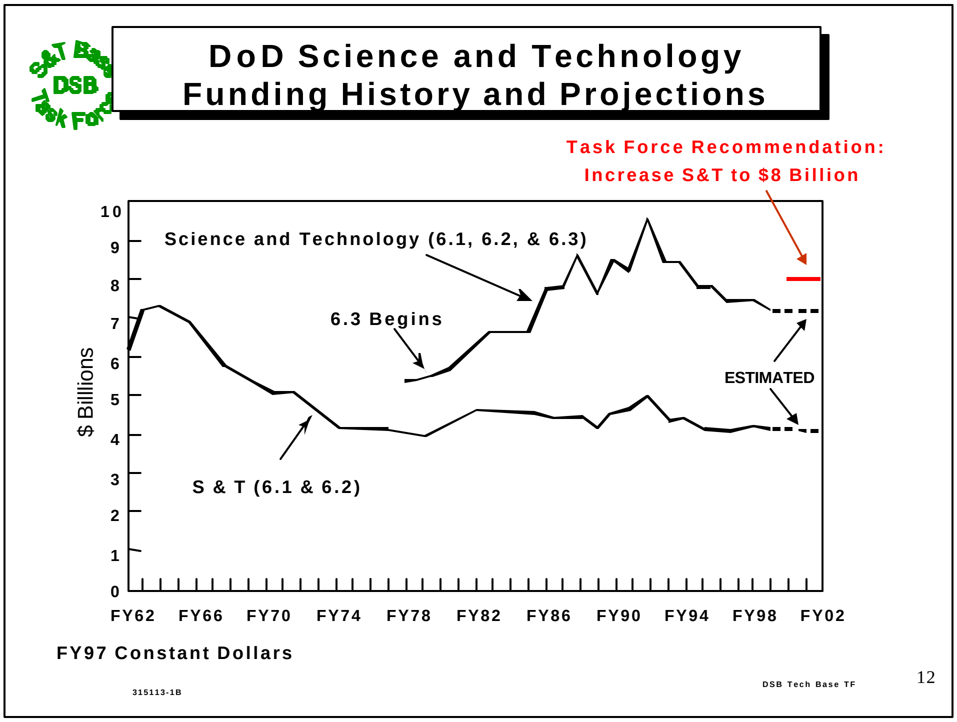

Fig. 3: DoD Science and Technology Funding History

Figure 3 indicates very large expenditures in the early 1960s when the Cold War was of major concern. By the 1970s the 6.1 and 6.2 funding had dropped from over $7 billion to a level of about $4 billion. The 6.3 category funding grew significantly during the 1980s with concerns about possible expansion of the USSR. After the breakup of the USSR, funding in this category declined significantly as well, again due to declines in the overall DoD funding. Recently, the funding in these two categories has continued to decrease significantly. The President's DoD budget segment for FY99 indicates a further drop in the S&T funding to about $7.2 billion.

C. Funding of Specific Technical Areas

The basic research funding of specific technical areas is shown in Figure 4. below.

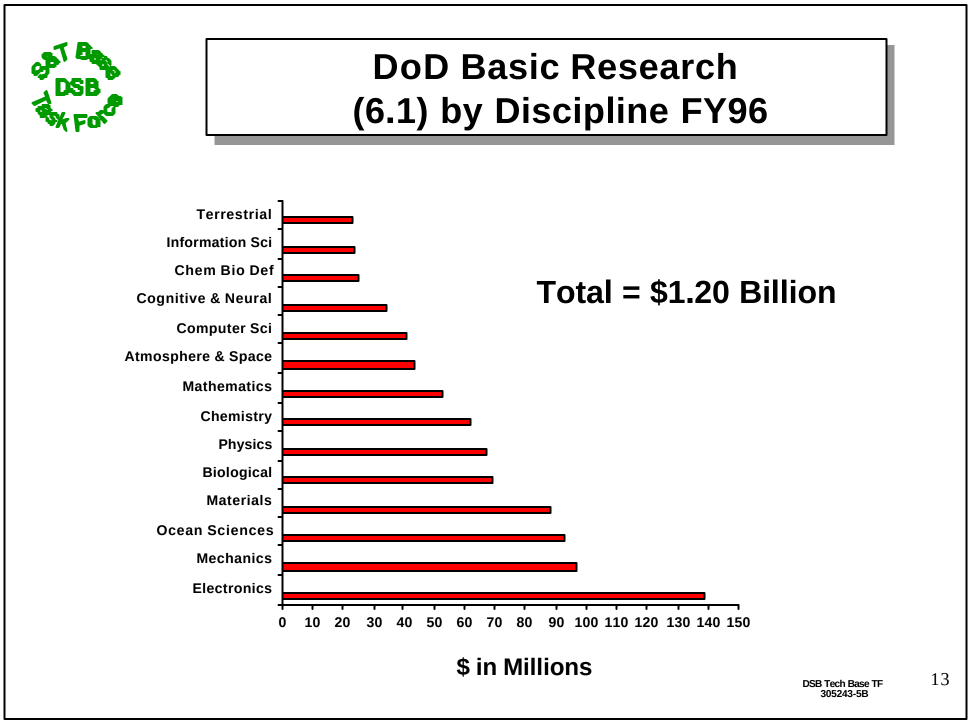

Fig. 4: DoD Basic Research Program Categories

Note emphasis on science areas having a major impact on DoD future technical capabilities. In some areas such as cognitive science, the DoD is the major national funding source. In others such as electronics, biology, and ocean sciences, the DoD supports the niche areas of these sciences which support primarily military applications. The DoD clearly benefits by basic scientific programs funded by other government agencies such as NSF, DOE, and NASA as well as private science funding and foreign basic science programs. However, the DoD 6.1 Basic Science Program remains of great significance to future U.S. military capabilities since the emphasis of the 6.1 program tends to be focused on engineering sciences, which are the bridge between the pure basic science discoveries and future military applications, which are the focus of the 6.2 and 6.3 programs.

The various technology areas funded under the 6.2 and 6.3 programs are shown in Figure 5 below. The emphasis in these programs is on technologies which support future DoD Systems.

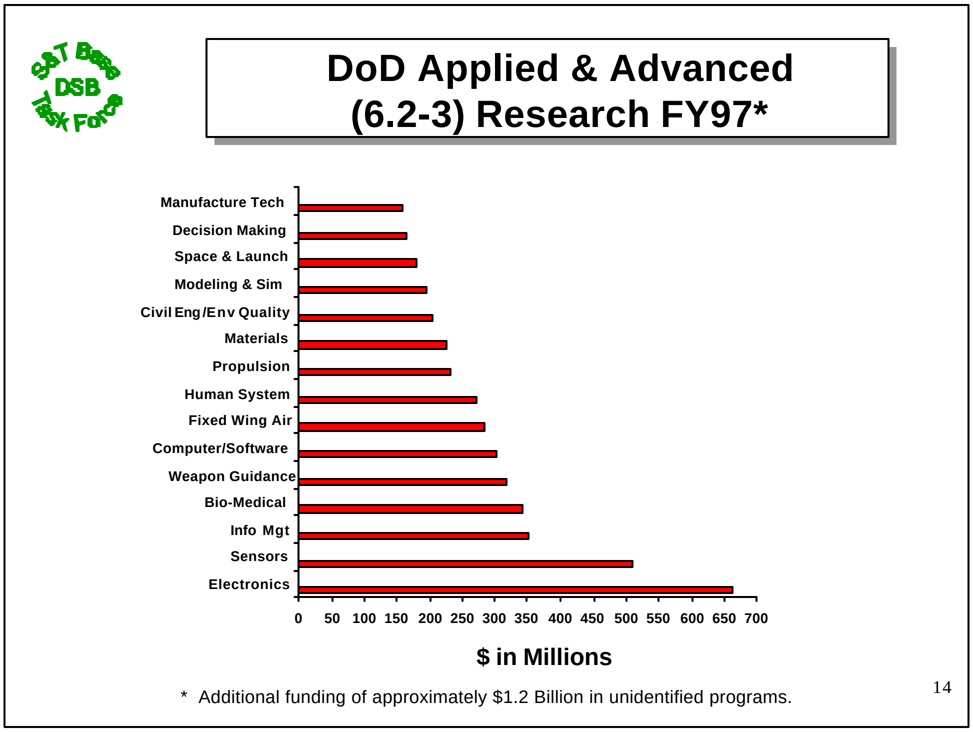

Fig. 5: DoD Applied and Advanced Research Program Categories

These 6.2 and 6.3 programs are becoming of increased importance to the DoD since many of the industrial applied research programs have, in recent years, been increasingly focused on short-term (3-5 year) market opportunities involving incremental technology improvements. The DoD applied research programs should focus on longer-term (10-20 year) major revolutionary changes in military technology.

III. FINDINGS AND OBSERVATIONS

A. Determining DoD Science and Technology Funding

The question of the proper level of DoD S&T investment is fundamental to maintaining future U.S. military capabilities. The Task Force was asked to determine whether there were any formulae in either industry or government that could be applied to answer the question of setting the level of investment. While the Task Force identified a number of indirect and subjective inferential methods used by industries to set the level of S&T investment, they found no formulas used in any of the 12 major corporations surveyed. Instead of an objective formula, there was a fairly universal subjective approach, where the Chief Executive Officer, Chief Financial Officer, Chief Technology Officer, and one or two others set the corporate levels of research and development investment. While the "smoke-filled room" may physically be a thing of the past, the basic approach of a few leaders setting the corporate objectives, financial goals, and investment strategy to meet the goals appears to be a common method.

From a global perspective, the reason an organization invests in science and technology is to gain a long-term advantage. For industry, the long-term advantage is economic. For the federal government, the goal is to ensure the nation's long-term economic prosperity and its national security. In the case of the Department of Defense, the additional goal is to gain an advantage in the balance of military power compared with potential adversaries. Figure 6 shows a model schematic diagram of the flow of technology base into military capability and ultimately combat outcome. The depiction makes the problem seem fairly simple and linear. There is a flow from the technology base through demonstration to development and production to military capability. This model demonstrates the investment in the technology base pays off in long-term military capability and balance of power. Unfortunately, expansion of this fairly simple schematic model into a mathematical representation requires the establishment of coefficients for multiple differential equations and their subsequent solution. The problem quickly becomes very complex. Appendix 3C contains the basic mathematical framework, but establishing the needed coefficients can prove to be a very difficult problem.

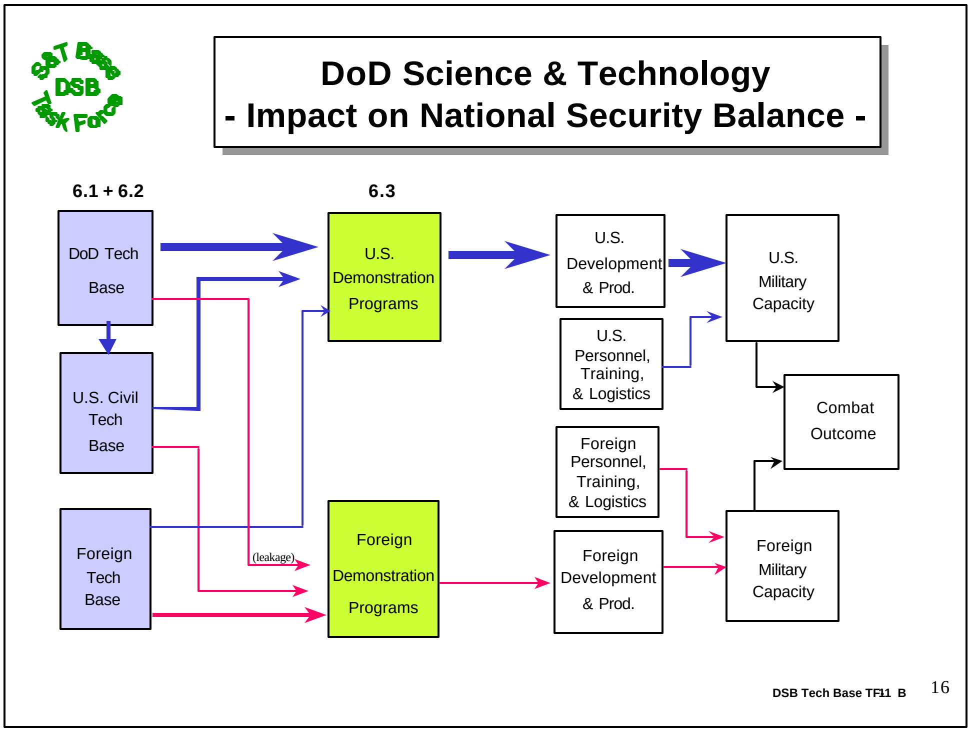

Fig. 6: Model schematic of the transition from Technology Base through Military Capability.

While an exact solution to this problem would be difficult at best, the model does highlight some important factors. At the conceptual level, the model infers the technology base strongly influences the long-term military balance-of-power. Thus, future United States military superiority requires the availability of a sufficient level of internal Department of Defense technology base which can be protected from leakage to potential adversary defense forces at least over the medium term (10-20 years).

Although the resultant U.S. military capability cannot be mapped linearly from the technology-base investment, the basic assumption is that there is a correlation between the total S&T base investment and the ultimate military capability. As the S&T investment increases, military capability also rises providing sufficient procurement investments are also made. But, as seen from the model, the technology base available for future U.S. military capability is a function of both DoD investment in S&T and general civilian S&T investment. A key point is that the civil-sector S&T investment by U.S. firms (and foreign firms) is becoming global — that is, there is leakage from the U.S. civil sector to assist foreign military capabilities. Thus, the primary investment applicable to providing unique U.S. military future capabilities comes from the DoD S&T component. A secondary contribution is made by the DoD S&T program through technology transfer to the U.S. civil technology base and from there back to DoD procurement of military systems.

Figure 7 shows the evolution of the DoD technology base (6.1 and 6.2)* investment over the past 40 years together with U.S. civil and selected foreign investments. Shown in Figure 8, the DoD technology-base investment has decreased as a fraction of the total from approximately 20% of the non-Soviet block global investment to approximately 5% of the global investment. Also shown is the decrease of DoD research relative to U.S. industrial research.

While much of the non-DoD research investment is not relevant to military capability, health care for instance, there is no denying that DoD has lost much of its research dominance since World War II. This implies that if the U.S. is to maintain a dominant military position in the future, it <u>must</u> continue to fund a strong military research program whose output level exceeds theirs, and is protected from leakage to potential adversaries.

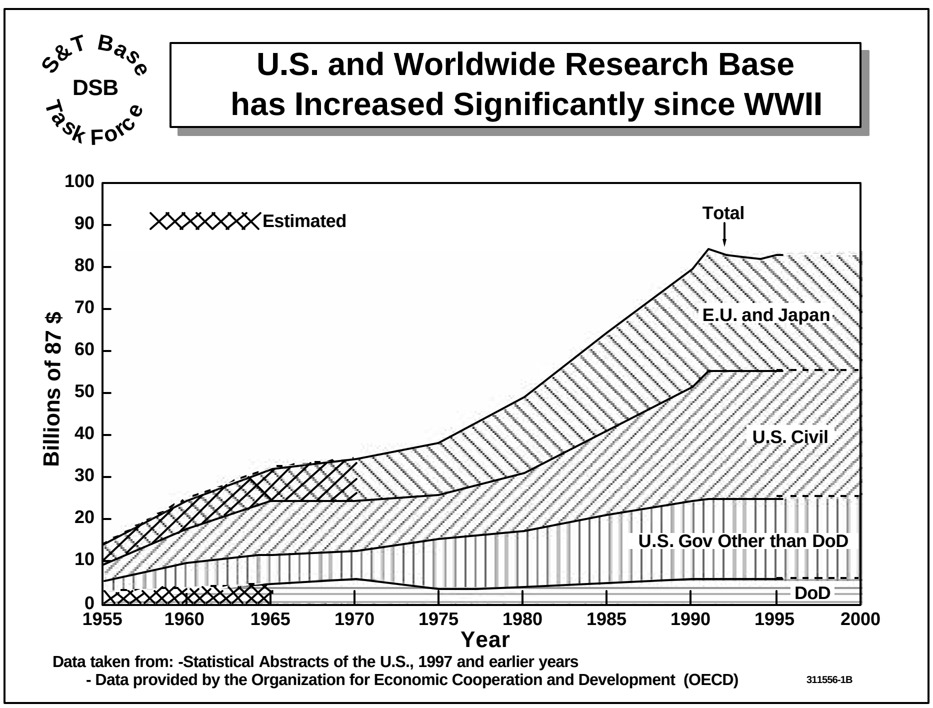

Fig. 7: Evolution of Global S&T investments.

* Only 6.1 and 6.2 funding data is available back to 1955.

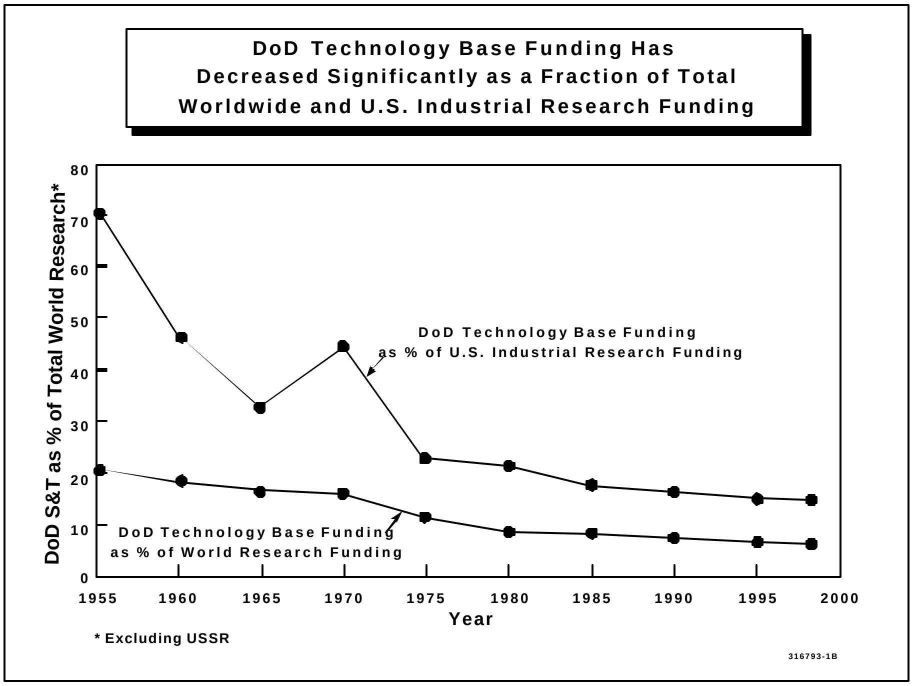

Fig. 8: Evolution of global S&T investment (percentage).

While the argument made above supports the concept that DoD research funding is critical to maintaining a strong national defense, there are still questions concerning how much funding is appropriate. The Task Force decided to look at industrial practices to obtain insight on this question.

The first principal observation is that industry does not manage its research and development process in a linear fashion as does the Department of Defense. By linear, it is meant that the flow of technical information is initiated in a basic research program (6.1) then flows to an applied research program (6.2) and thence by unidirectional flow to 6.3, 6.4, etc., finally resulting in a military capability. Instead, the model used by industry is a dynamic, non-linear model as depicted in Figure 9.

As can be seen from Figure 9, there is not a step-by-step transition from basic research to advanced research to advanced concept development to engineering and then manufacturing.

Current industrial practice involves close interactions between research, development, marketing (requirements) and production. While there may indeed be some “linear” flow from research to marketing, an equally likely flow might be for marketing to influence new directions for basic research.

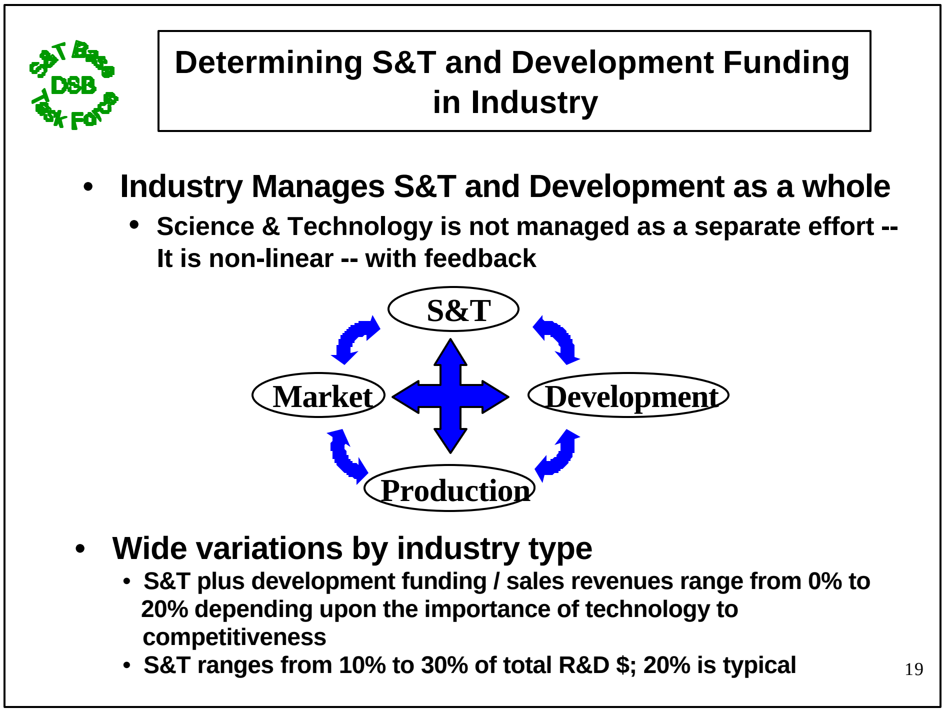

Fig. 9: Industrial practices for managing and setting funding for S&T and development.

As a result, the level of funding for industrial research is often set on the basis of potential market demand, and hence future profits for the organization.

Since potential new markets vary with the maturity of an industry, it would be expected that a wide variance would occur in the percentage of sales revenue devoted to research (S&T) and development in different industries. Such is the observed situation which will be discussed next.

Figure 10 shows research and development of expenditures for a variety of industries. The data was gathered by the Association of Industrial Research Institute. The plot shows the percentage of sales devoted to total research and development for each industry with the maximum, minimum, and mean values plotted. The percentage of revenue devoted to research and development ranges from near zero for coal and petroleum products to well over 15% for pharmaceutical firms. The percentage of revenue devoted to research only ranges from less than 0.1% to about 3.4% for high-technology industries such as pharmaceuticals. For DoD, the FY98 R&D percentage is derived from R&D funding of about $36B out of a total T.O.A. of about $250B. The S&T funding of 2.9% of T.O.A. is derived from S&T funding of $7.4 B.

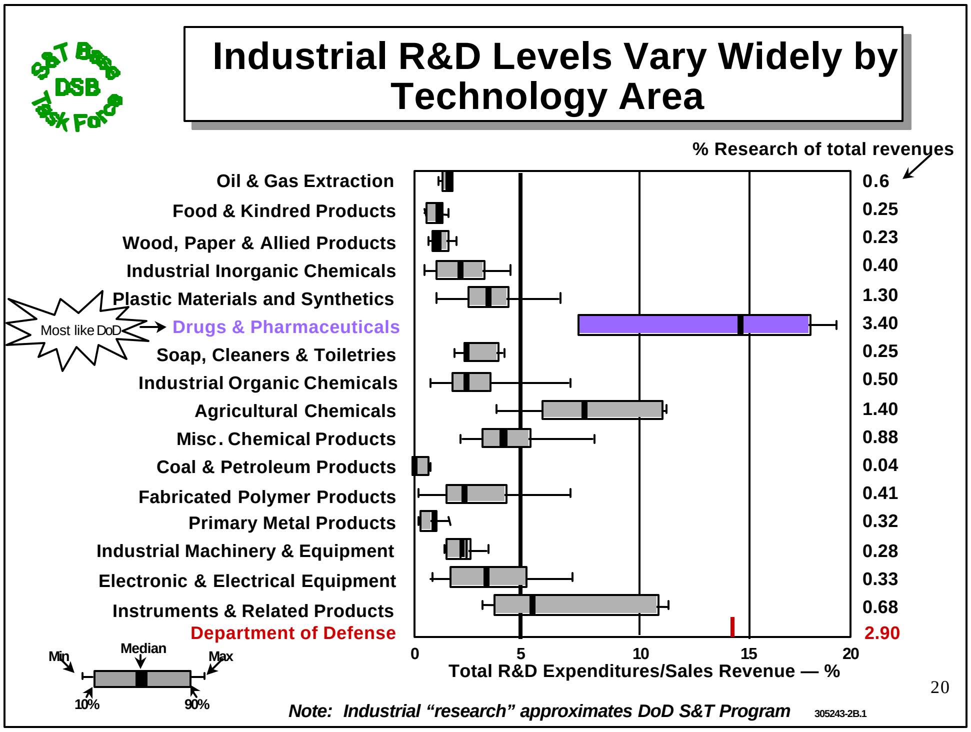

Figure 10: Industrial sector investment in total R&D and research as a percent of total revenues.

The basic situation for industries who compete each day for markets is different from the military services who focus on national security and only very seldom are tested in combat. However, it is worthwhile trying to identify which industry group is most similar to DoD and its challenges. The success of most of the industries listed depends more on their ability to compete on price and marketing since they often have difficulty establishing intellectual property monopolies due to lapsed patents, circumvention of patents, and cross-licensing.

However, in the case of pharmaceutical industries and leading computer technology industries the R&D funding as a percentage of revenue is considerably higher, about 15% (see Figure 11). For these firms, patents do provide absolute market protection for the life of the patent (20 years) and hence provide enormous commercial advantages. This advantage is similar to that achieved by a military force which develops a unique technical capability which is protected over many years by a combination of secrecy, restricted publications, closed technical exchange meetings, export laws, and other mechanisms.

R&D Funding by High-Technology Firms Averages Over 15%

(1994 data from Science & Engineering Indicators)

Pfizer	13.8%	National Semiconductor	11.2%
Abbot Laboratories	10.5	Lotus	26.3
Lilly	15.7	Oracle Systems	11.8
Scherring-Pough	13.3	Computer Associates	10.5
Phone-Poulenc Rorer	14.6	Amdahl	12.4
Microsoft	13.1	Applied Materials	11.4
Upjohn	18.2	Silicon Graphics	12.0
Marion Merril Dow	15.1	Storage Technology	10.5
Novell	17.4	Chiron	44.7
Amgen	19.6	Meditronic	11.2
Genetech	40.8	Tektronic	11.6
Tandem Computers	14.5	DSC Communications	14.6
Advanced Micro Devices	13.1	Cray	15.3
		Intergraph	13.2

Overall Average 16.3% of Revenue

Fig. 11: R&D Funding of Leading U.S. Technology Industries

Using the pharmaceutical industry as a model, Figure 10 shows about 14% of revenue devoted to research and development. With current DoD funding of about \$250 billion, a total DoD research and development funding level of about \$35 billion is indicated or close to the current DoD level. The DoD S&T budget corresponds most closely to the research component of industrial R&D. Using 3.4% of revenue (typical of high-tech industries shown in Figure 11), the DoD S&T funding should be about <u>\$8.4 billion,</u> which is <u>a billion dollars greater than the FY98 S&T funding</u>.

Another approach to this question is to note that the ratio of research funding to total R&D funding in high-technology industries, such as pharmaceuticals, is about 24% (3.4%÷14%). When this percentage ratio is applied to the FY98 R&D funding of about \$36B, the result is about \$8.6B, well above the actual S&T funding.

These considerations lead to the conclusion that there should be <u>no further reductions in the level of S&T funding</u>. In fact, there is <u>some basis for an increased level</u> to at least \$8B in order to insure the continued long-term technical superiority of U.S. military forces in the 21st century.

While the pharmaceutical and other high-technology industrial models suggests a level of S&T funding higher than current DoD funding, there are other important lessons from industry that need discussion. Perhaps foremost, the industrial representatives that addressed the Task Force were nearly unanimous in stating that maintaining the productivity of S&T programs requires stability in funding.

For the most part, industry sets S&T investment by starting with the previous year's funding level, then adjusting the amount incrementally, depending upon the identification of new technical and marketing opportunities for the firm. This suggests DoD S&T funding should move incrementally up or down from the previous year's funding, based on new military challenges and on new technical opportunities. Industry sets this level of investment by having the industrial executives look at factors such as market opportunity, level of potential economic payoff, and ability to keep from losing a major market segment if the industry does not keep pace with a major change.

History is full of examples where firms lost their market dominance by failing to invest in change. For instance, steam locomotive manufacturers all went out of business within one or two decades of the time that diesel locomotives were introduced by other industries having expertise in electric drives and diesel prime movers. A more recent example is that of electronic cash registers which drove mechanical calculator industries out of business. Thus, DoD needs to ensure an adequate S&T investment to minimize the risk of an adversary developing a capability that puts the U.S. at a national security disadvantage.

Another important industry practice noted by the Task Force was that of allocating about 1/3 of the total available research funding to exploratory or potentially revolutionary projects. The other 2/3 of the effort is typically focused on identified product needs in the form of evolutionary improvements in current product lines.

Summary Observations

The observations concerning the topic of S&T funding level and its determination can be summarized as follows:

- DoD S&T is vital to future of U.S. military balance of power. Over the past century, technical developments funded by the military have had an enormous impact on military capabilities and have been decisive in the outcome of conflicts.

- No formulas for establishing S&T funding have been discovered either in government agencies or in industry. An analytic framework for establishing R&D funding can be formulated, but the coefficients of the equation terms are not known at this time.

- Industrial R&D funding (including the research or S&T component) tends to be set in meetings of the CEO, CFO, CTO, and senior vice presidents.

- Industrial decisions on S&T funding are influenced by potential return on investment, competitiveness, and strategic objectives.

- Industrial R&D is growing relative to DoD but it is predominantly short-term in focus.

- Current DoD science & technology funding (about 2.9% of total DoD funding) is somewhat less than the practice of those high-technology industries which are dependent on technology supremacy or patent monopolies for commercial success.

- Lower levels of DoD S&T funding could threaten future (20 years and beyond) dominance of U.S. military forces.

- Continuity of science and technology funding level is thought important in most industries (to prevent disruption of programs and research teams).

- One-third of industry research is typically exploratory and focused on revolutionary technologies whereas two-thirds is focused on evolutionary improvements in identified product needs.

B. Management of the DoD Science and Technology Program

1. *Organizational Structure*

To address this question, the Task Force looked at both current DoD management and industrial models. Figure 12 is a simplified schematic of the current DoD management structure, indicating separately the flow of funding, policy and command. Not shown are the separate Service (6.1) organizations, ONR, AFOSR, and the ASO, which manage university defense research programs. To call the current structure complex is an understatement. Compounding this complexity is the geographic separation of the laboratories from the management and each other. The executing laboratories are displayed as ovals under the Central Service

laboratory management organizations. Thus, even though the Air Force has recently restructured to a single Lab structure, the Air Force Research Lab, it still maintains nine geographically dispersed structures.

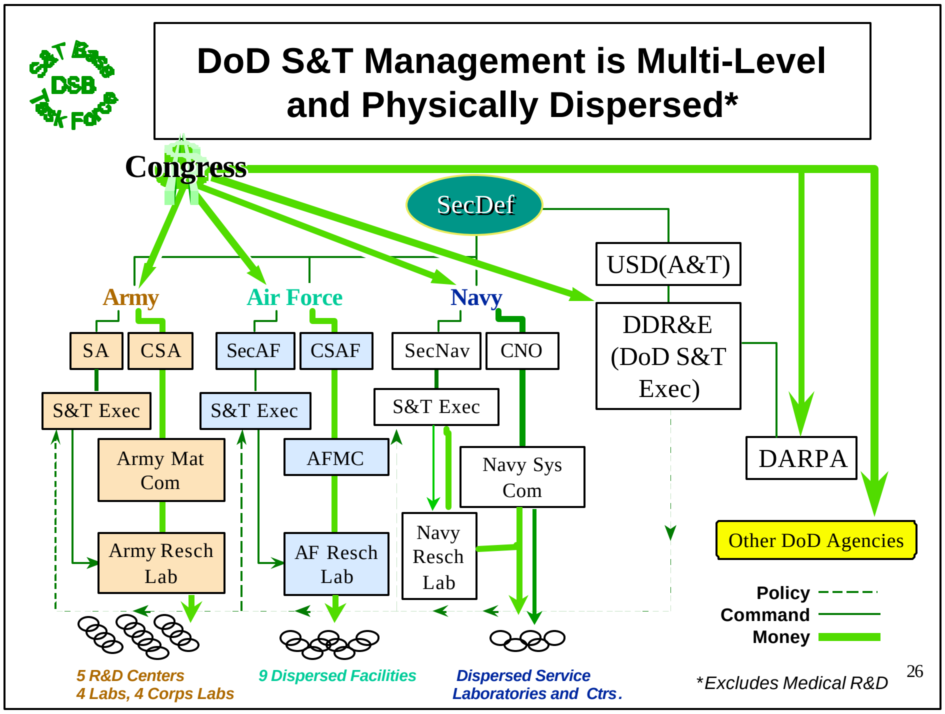

Fig. 12: DoD Laboratory Management Structure.

Comparing the complexity of the DoD labs with a sample industrial laboratory management structure, shown in Figure 13, it is fairly easy to see the contrasting simplicity of the civilian management structure. In the civilian research management structure, it can be seen that there are far fewer layers of management from the Chief Executive Officer to the laboratory workers. The example used here is Dupont, although other companies with major R&D investment have similar structures.

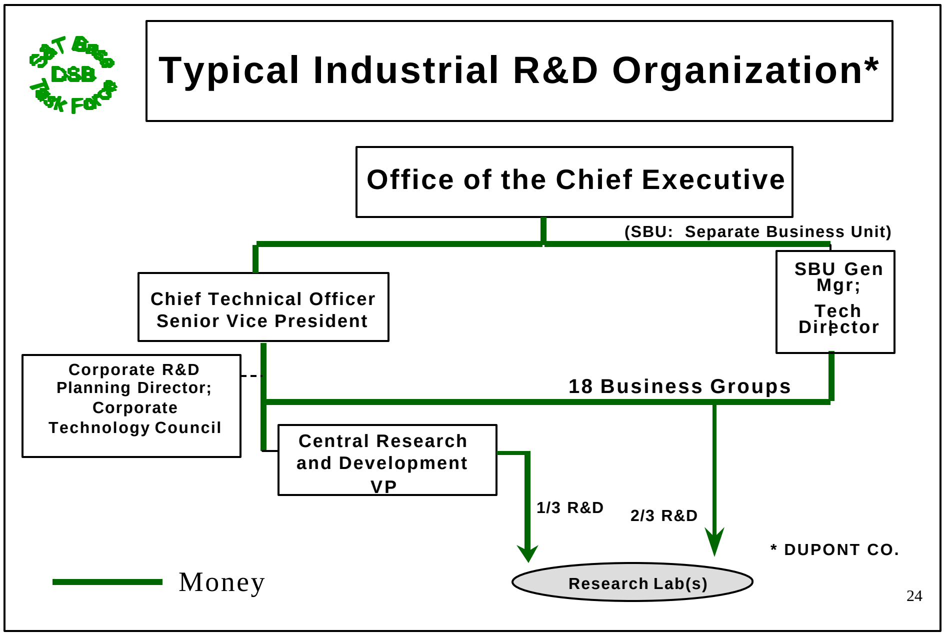

Fig. 13: Sample industrial lab.

2. *Quality of S&T Management Personnel*

The productivity of the DoD S&T program is greatly dependent on the quality of the OSD and Service S&T management. In the more distant past, Public Law 313 allowed the recruitment for limited terms of extremely capable scientists and engineers from universities and industry. As a result, very significant innovative military capabilities were pursued under the S&T program. With the cancellation of P.L. 313 in 1978, the Department was no longer able to recruit scientific and engineering personnel from industry for non-presidential appointment positions.

3. *Funding Balance*

There is another significant change in DoD S&T management that has emerged over the past 10 years. During this period, the Service S&T budgets have eroded while the budget of the Office of the Secretary of Defense and Defense agencies has grown, see Figure 14.

A major reason that Service S&T budgets have declined is because the Services have chosen to emphasize current operations. The Defense-wide growth is a result of the evolution of DARPA's programs as well as growth of other Defense programs such as ballistic missile defense and chemical/biological warfare defense S&T programs. This shift in funding to

OSD and defense agencies raises issues of whether the Services have sufficient funding to properly address their long-term technology needs.

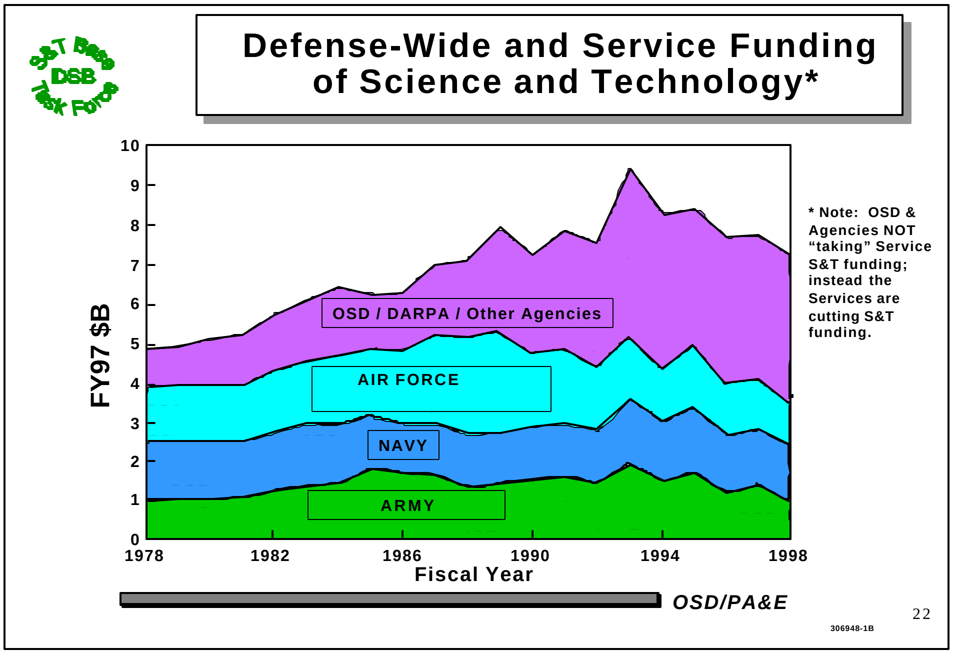

Fig. 14: Distribution of S&T Funding

4. *Transition Issues*

One final observation that the Task Force made concerns the difficulty of transitioning OSD and DARPA programs to acquisition programs. Under Title 10, United States Code, the military Services are responsible for system acquisition and are more likely to develop a transition path from their laboratory programs into acquisition. Such an acquisition path does not exist for DARPA and OSD S&T programs. Consequently, there is an increasing portion of the S&T budget that does not have a clear transition path from research to fielding of military systems. This trend means that a number of successful programs developed by DARPA may never end up transitioning to warfighting systems. The Task Force suggests that the DDR&E be given an expanded authority over 6.4 and 6.5 programs to insure that the Services fund the development of successful S&T programs developed under both OSD and Service oversight.

Summary Observations

The observations concerning the management of defense S&T funding can be summarized as follows:

- Successful industries manage research and development with efficient organizations involving a minimum of levels of administration.

- DoD S&T management is highly complex involving many levels of administration.

- OSD's portion (including DARPA) has steadily increased to 50% of the total S&T program raising questions about the adequacy of the Service S&T programs.

- Within DoD, DARPA particularly enjoys success in research management because they can initiate new research relatively easily and employ innovative research managers through the use of limited-term personnel drawn from the private sector. However, DARPA often has difficulty transitioning successful programs because of the lack of follow-on acquisition programs in the Services or OSD.

C. Execution of the DoD Science and Technology Program

1. *Industrial Research Laboratory Practices*

The Task Force reviewed in some detail the practices of the industrial sector firms interviewed with respect to scientific research and technology development.

Their practices can be summarized as follows:

- hire and nurture very high-quality technical staff from graduates of world-class research universities;

- compensate quality technical staff performance and terminate low performers;

- provide up-to-date laboratory facilities;

- provide adequate supporting personnel, both technical and administrative;

- consolidate research and development programs in the same physical location to enhance technology transfer.

Each of these topics is discussed in the following sections in more detail:

a. *Hiring Technical Staff* (See Section D, page 32).

b. *Evaluation and Compensation* (See Section D, page 32).

c. *Laboratory Facilities*

The staff are provided with up-to-date research facilities in successful industrial laboratories. Funding for this purpose is typically provided directly to the staff and their leaders thus enabling them to decide for themselves what equipment will best enhance their research.

d. *Supporting Personnel*

The technical staff of successful industrial research laboratories are typically supported by both a technical assistant in the form of a technician or software specialist and the equivalent of another person in administrative services, i.e., library, purchasing, publications, building maintenance, etc.

e. *Location of Laboratory Facilities*

In order to enhance the transfer of technology from the research laboratory to product developments, successful industries very often physically place their research laboratories adjacent to product development organizations. This enables easy communication between the two organizations, and, where desirable, allows the research workers to take their innovations into the development stage and even production. Figure 15 shows the physical integration of both research and development employed by Dupont. Similar arrangements exist for many other successful industrial organizations such as Pfizer, 3M, and Merck.

Successful Technology Organizations Often Locate Research with Development & Production Operations

DuPont Experimental Station, 150 acre R&D Site, founded ca.1903
- **All key activities collocated**

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Fig 15: Dupont Consolidated Research and Development Facility

2. *Current Execution of the DoD S&T Program*

a. *Performing Organizations*

Figure 16 indicates that currently, the DoD S&T Program is executed by a variety of performers. The 6.1 Basic Research Program is primarily executed by the universities. The 6.2 Applied Research Program is primarily executed by the DoD/Service laboratories with lesser amounts going to industries. The 6.3, Advanced Technology Development Program is primarily executed in industries with lesser amounts going to university research centers and FFRDCs.

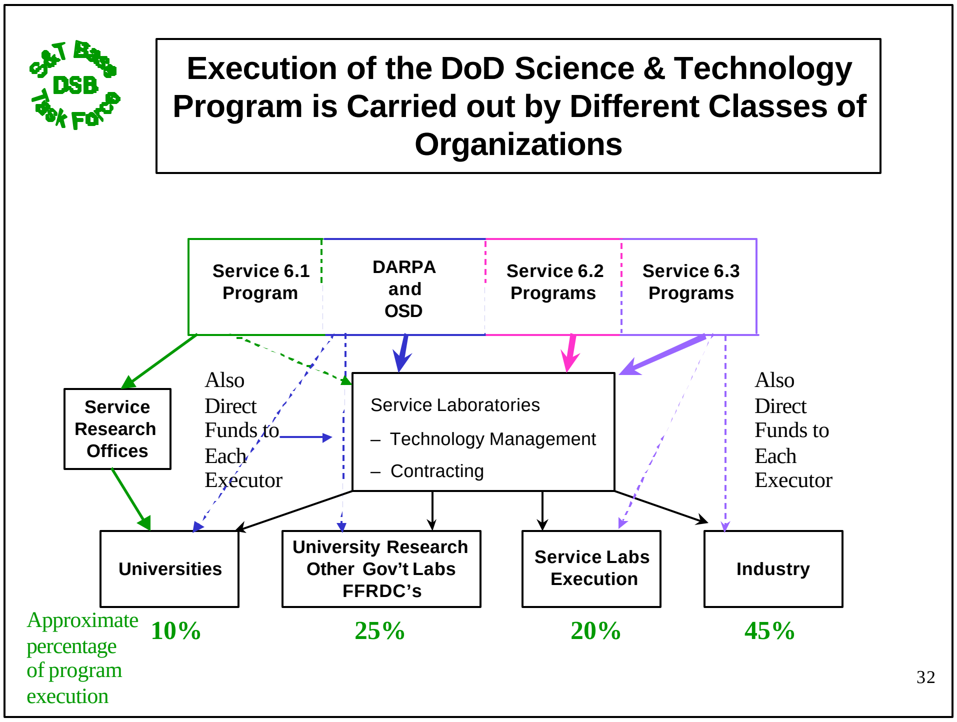

Fig. 16: Execution of the DoD Science & Technology Program is Carried out by Different Classes of Organizations

While perhaps only 20% of the S&T Program is executed by DoD/Service laboratories, the management and placement of the 6.2 and 6.3 programs is handled by the DoD/Service laboratories, hence they play an important role in the S&T program.

The Task Force discovered that there is general satisfaction with the quality of execution in both the universities and in industry. However, many prior studies have indicated significant concern about the quality of execution in many of the Service laboratories. The Task Force believes that several factors lie behind this problem.

Physically, DoD/Service laboratories are dispersed across the continental U.S. in a variety of locations, which are mostly the result of World War II and even World War I needs (see Figure 17).

In many cases, the Service development/product centers are located in still other locations and are often separated by hundreds if not thousands of miles from the Service research laboratories. These physical separations make the transfer of technology much more difficult than in the case of successful industrial organizations, which employ consolidated R&D facilities.

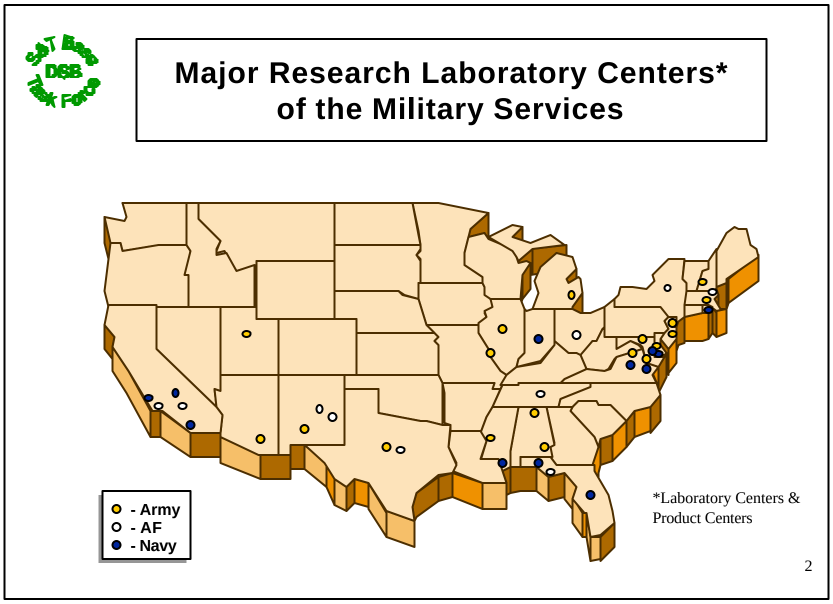

Fig. 17: Major DoD Laboratory Facilities

b. <u>Personnel System</u>

Because of limitations imposed by civil service personnel regulations those it has become increasingly difficult to hire and maintain high-quality technical staff for the Service laboratories.

The Department has commissioned several dozen studies of this problem extending over several decades. All these studies have reached the same conclusion, namely that there are severe difficulties in maintaining technical staff quality in the Service laboratories under the current Civil-Service system.

The following section (III-D) of this report discusses the details of this very serious problem.

In addition to the problem discussed above, there are also two more problems that inhibit the effectiveness of DoD/Service laboratories. The first deals with the issue of research facilities.

d. *Facilities*

Many of the Service laboratories were built several decades ago in the period after World War II. While many have been rehabilitated in recent years, many remain unattractive as places of employment for the more capable technical graduates of leading universities. In addition, the technical facilities and instrumentation of many of these laboratories have become outdated as compared with industrial or university laboratories.

e. *Supporting Personnel*

Another serious problem is the lack of supporting technical personnel. During the recent reductions-in-force, the tendency has been to retain as many research technical staff as possible. Thus, the burden of the personnel reductions initially fell upon the support staff with the result that the productivity of the remaining technical staff has been greatly impacted.

Summary Observations

- The DoD S&T Program is executed by a variety of organizations: universities, university research centers (FFRDCs/non-profits), military Service laboratories, other government laboratories, and industry.
- While the program execution by private sector organizations is generally satisfactory, the performance of many of the Service laboratories is a matter of serious concern.
- Effective execution of the S&T program by the Service laboratories is severely impacted by the constraints of the Civil-Service regulations on the professional staff of these laboratories.
- The Service laboratories and other executors of the S&T program are physically widely dispersed and are often separated from government development centers as well as defense industrial developers, thus making technology transfer difficult.
- In addition, the Service laboratories' effectiveness is also significantly impacted in many cases by outdated facilities and technical equipment as well as by lack of adequate technical support staff.

D. Ability of DoD and Services to Obtain and Retain Scientists and Engineers

The previous sections have referred to the impact of Civil-Service regulations on the professional staff of DoD/Service S&T management and execution organizations (laboratories). In this section of the report, private-sector industrial laboratory personnel practices will first be examined followed by a review of the government Civil-Service personnel practices and their impact on the ability to attract competent engineers and scientists to DoD laboratories and S&T management. Finally, several alternative personnel systems will be examined.

1. Industrial Scientific/Technical Personnel Practices

The Task Force found that most industrial research and development organizations employed similar personnel practices which could be summarized as follows:

a. *Hiring*

Successful technical industrial firms use their technical staff to recruit intensively at leading technical universities each year.

The most promising students are promptly made salary offers competitive with the current market for scientific/engineering staff.

b. *Evaluation and Compensation*

The performance of industrial scientific and technical employees is typically evaluated once per year. Feedback in the form of evaluation ratings, letters and discussions is quite often provided. Often scientific personnel are ranked in order with the best performers at the top and the poorest at the bottom.

Annual salary increases are awarded with the increases roughly in proportion to the ranking; that is, those at the top of the ranking receive perhaps twice the average and those at the bottom much less than the average.

c. *Terminations*

Poor performing staff are advised of the need for improvement if they are to have successful careers. Those that do not respond are then asked to leave.

2. Civil Service Personnel Practices

DoD/Services technical personnel involved with the management and carrying out of the DoD S&T Program labor under the regulations of the Civil Service Reform Act of 1978 (PL 95-454). This Act replaced prior legislation, including the 1947 Public Law 313, which permitted the Service Secretaries:

- to establish certain positions for important DoD R&D functions,
- to make such appointments without competitive examination,
- to pay market rates for these positions.

The 1978 Act set up the Senior Executive Service (SES) positions in a fashion that severely limited the ability of OSD and the Services to temporarily hire very capable scientists and engineers from the private sector including both industries and universities.

This change in the Civil Service legislation has had a significant impact on the S&T management structure of OSD and the Services.

An exception has been DARPA, which has made extensive use of the Interagency Personnel Act of 1971 (IPA), which allows non-profit organizations such as universities, to temporarily loan scientific/ engineering personnel to DoD agencies and the Services. The IPA Act, however, does not permit temporary loan of personnel from private sector profit-making organizations.

In spite of this limitation, DARPA has been able to maintain a vital and vibrant S&T management environment using IPAs to staff over half of their technical organization.

The rest of the Department depends, for the most part, on the Civil Service Personnel System to staff its S&T management and execution positions. This system fails to adequately service Civil-Service scientific and engineering employees and the Department of Defense in several important ways, which can be summarized as follows:

- It fails to allow salary offers to be made at market salary rates and in a prompt fashion.

- It fails to permit evaluation of scientific personnel properly and to award salary increases in proportion to employee contributions.
- It fails to provide timely and workable mechanisms to terminate unsatisfactory employees.

Each of these points are discussed in more detail below.

a. *Hiring*

Figure 18 plots the current salary levels of the Civil Service GS-9, -11, -14, and -15 grades as a function of years-of-service after obtaining MS or PhD degrees as compared with the current private sector average salary levels for MS and PhD graduates. Typically, Civil Service salary offers for MS graduates are made at the GS-9 or GS-11 levels. It can be seen that the Civil Service offerings are at least $10,000 below the market. For PhD graduates, the GS-13 offer is $15,000 below the market. Furthermore, a long competitive process is typically employed before an offer is made by the government. By that time an offer from the private sector has usually been accepted by most potential applicants.

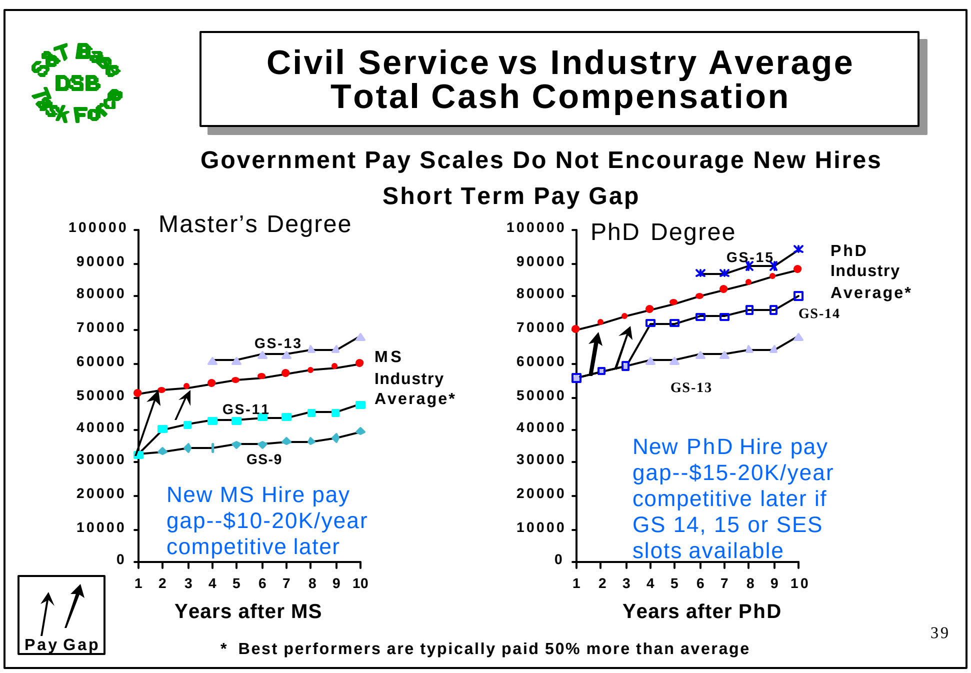

Fig. 18: U.S. Civil Service vs. Industrial Salary Levels

The result is that Service laboratories can hire virtually no advanced degree graduates. Some BS-degree recruitment is possible because GS-9 salaries are competitive with the private sector, but such graduates usually are not as competitive as advanced degree graduates are and are not often sought by private sector laboratories except for supporting positions.

Further examination of the GS-14, GS-15, and SES salary levels indicates that even these grades are not competitive with the private sector salaries paid to scientists and engineers with managerial responsibilities.

b. *Evaluation and Compensation*

Under the traditional Civil Service evaluation systems, most employees are rated either excellent or good in order to allow the customary step salary and inflationary increases to be given and to avoid controversy. The result is that the really excellent employees are not rewarded sufficiently while poor performing personnel are usually rewarded with nominal salary increases because of the complexity of Civil-Service processes required to justify low or zero-salary increases.

c. *Termination of Poor Performers*

As a result of the typical evaluation systems employed, combined with automatic salary increases, those employees who are not performing satisfactorily are retained. This is especially the case since termination proceedings are very difficult to successfully undertake because of the lengthily bureaucratic proceedings.

3. Impact of the Civil Service System

Figure 19 shows the results of a demographic model illustrating the impact of retaining poor performers in contrast to a personnel system in which good performers are retained and the poor ones terminated. Not unexpectedly, a steady accumulation of poor performers occurs with time in an organization in which it is difficult to terminate poor performers. In addition, the number of top performers tends to steadily decrease because they become discouraged about the future of the organization.

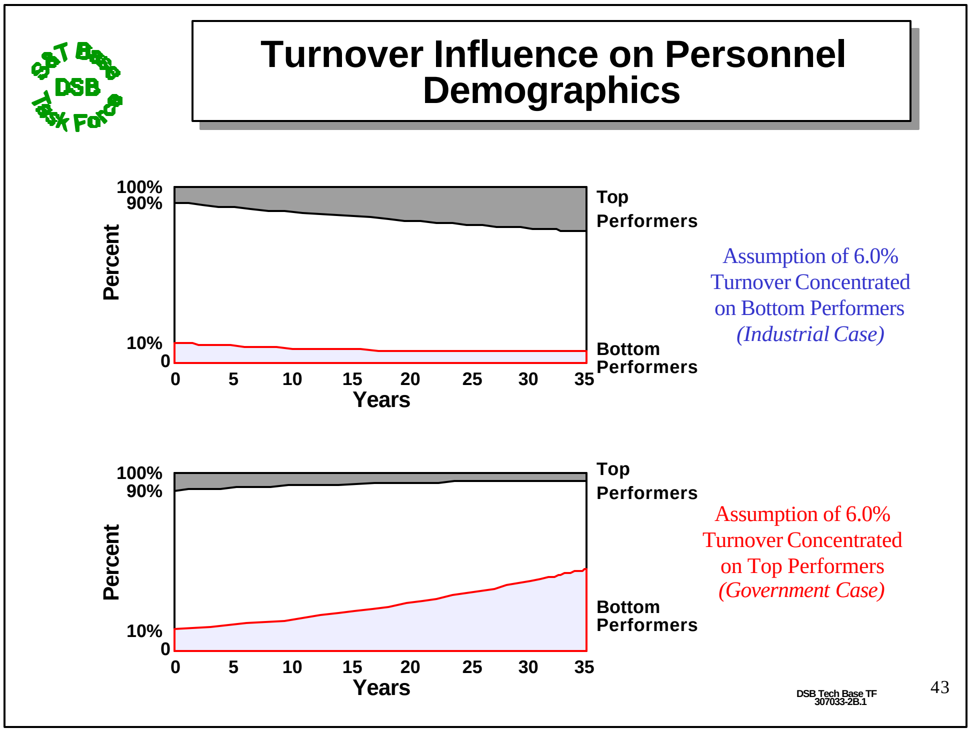

Fig. 19: Turnover Policy Impact on Organizational Demographics

4. *Impact of Downsizing*

Added to the effects of the poor Civil-Service personnel policies described above, has been the impact of downsizing DoD laboratories in recent years. If annual downsizing equal to or greater than normal retirement is forced on a laboratory, it is not possible to do any hiring at all. Even worse, the reductions fall entirely on the youngest employees because of seniority rules. The result is a steady increase in the average age. Ultimately, the organization heads towards collapse when the increasingly older employees retire.

Figure 20 shows a plot of the number of employees and average age with time for one of the leading Service laboratories. The recently forced rapid decrease in number of employees has had a dramatic rapid increase in average age, particularly in the last year.

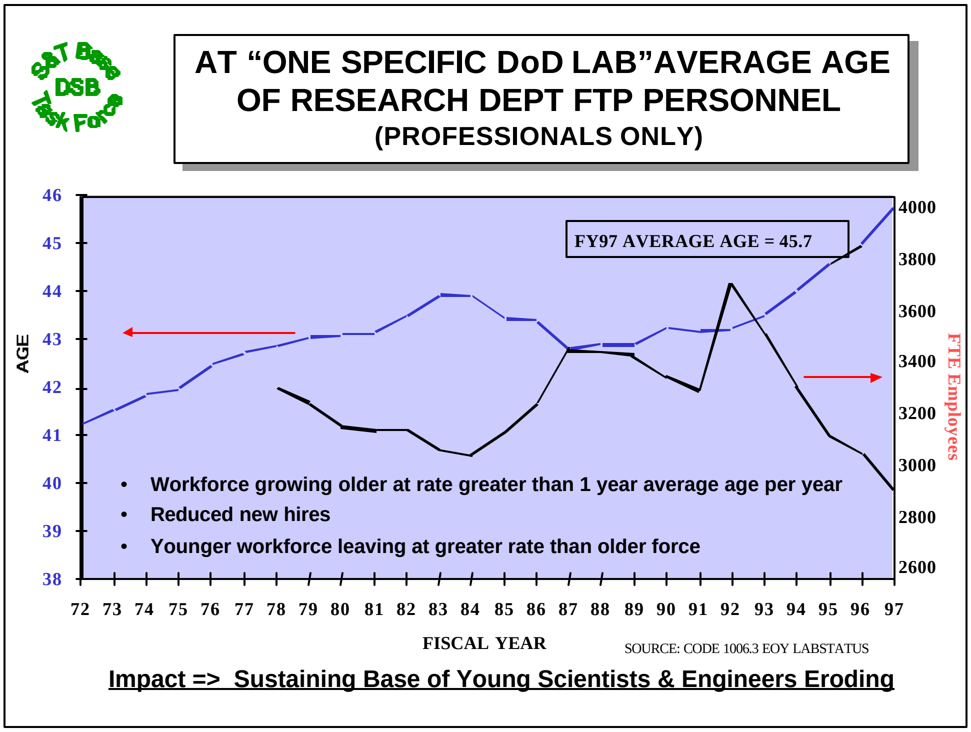

Fig. 20: Impact of DoD Personnel Policies on a DoD Laboratory

5. Possible Solutions

The Task Force has identified three possible solutions to these problems:

- Modification of the current Civil Service System,
- Transition of the laboratories to government-owned/civilian-operated (GOCO) status,
- Transition to mixed organizations with government leadership but staffed primarily with private-sector employees on a rotational basis.

Figure 21 shows the pros and cons of these three alternatives. Each of these options are discussed further below.

Options for DoD Laboratories

- There are at least 3 different options to improve effectiveness of DoD labs:
  - Keep current structure but modify civil service personnel policies and other DoD regulations.
  - Convert the DoD laboratories into university or contractor-operated organizations.
  - Transform a major portion of Service-laboratory personnel to non-Civil-Service personnel such as IPAs, university visiting faculty, and industrial scientists.

	Maintain Current Structure	Government Owned, Private-Sector Operated (DoE Mode)	Government lead, Private-Sector Aided (Rotational Postings)
PRO	• Minimal Disruptions	• High quality technical staff • Improved facilities	• High quality technical staff • Retains Military coupling
CON	• Incremental improvement only	• Politically Difficult • Decouples Military from Lab	• Implementation Slow

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Fig. 21: Options for Improving the Quality of DoD/Service Laboratories

a. *Modified Civil Service System*

In recent years, Congress has authorized experimental modifications to the Civil Service System. These have been implemented in some, but not all, DoD/Service laboratories. The details differ from case to case, but generally encompass the following:

- Banding of the GS grades to permit easier hiring of bachelor-degree graduates,
- Onsite (laboratory) authorization to hire without a competition throughout the government,
- The use of personnel evaluations based on performance including the use of ranking,
- Salary increases related to performance,
- Negligible relaxation of personnel termination proceedings.

These modifications are certainly an improvement over the previous system. The wider salary bands are helpful, but because of the cap on the numbers of GS-14s , GS-15s, and SES positions, the resulting hiring salaries (GS-13 and below) are still not competitive with those offered by industry at the graduate-degree level. Finally, the difficulty in terminating poor performers remains. The Task Force believes that these changes, while helpful, are simply not sufficient to solve the problem of providing adequate numbers of capable scientists and engineers to the DoD and the Services.

b. GOCO Option

Under this option, the provision of OSD/Service S&T management and laboratory personnel would be turned over to private organizations, either universities or industrial. While this option would certainly solve the problem of Civil Service constraints on salaries, employee compensation, and termination, it would not provide a satisfactory solution to the S&T high-level management function since this function should remain with the government.

In addition, experience has indicated that serious political difficulties can arise from a forced change of laboratory employees from Civil-Service status to private employment because of pension and other benefit issues.

c. Government Leadership – Private Sector Staffing

The third option combines military/civil servant leadership with extensive (>50%) use of private sector scientists and engineers supplied on a rotational basis from universities as IPAs as well as from industry on a contract basis. This option is already successfully used by DARPA as shown in Figure 22, but it is not unique with DARPA. It has been used for the operation of the Kwajalein Missile Range, the Tullahoma wind tunnel facility, as well as a joint-battle-staff training facility that ACOM operates.

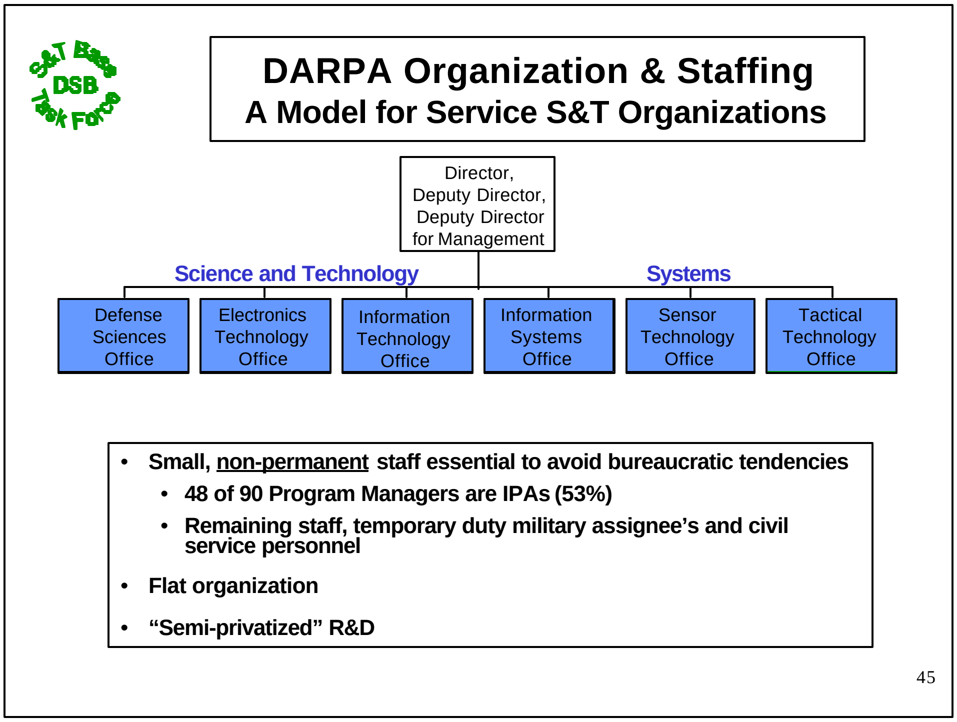

Fig. 22: DARPA Organization and Staffing

5. Task Force Views

After considering the three options described, the Task Force strongly supports the third option.

Summary Observations

- The private sector is able to hire very competent scientific and engineering personnel by offering market salaries, using effective evaluation and compensation systems as well as promptly terminating unsatisfactory employees.

- With the current Civil Service regulations, the DoD and the Services cannot hire highly competent scientific and engineering staffs for management and laboratory operations. Further, it is still very difficult to terminate unsatisfactory employees.

- As a result, serious deterioration of the capabilities of DoD/Service S&T operations has occurred.

- Of the three options for solving this problem, the Task Force believes that only the last option involving government leadership with private sector staffing of most of the professional positions is viable.

E. High-Leverage Technology

The final question asked of the Task Force is fundamental to maintaining military superiority. Even if the Department of Defense was to implement all the personnel and organizational changes the Task Force recommended in the earlier sections of the report, there is still the issue of balancing the S&T program between short-term evolutionary improvements in current systems and longer-term investments in revolutionary technology.

Current military strategists believe there is a Revolution in Military Affairs ongoing, and that the world may be entering a period of fundamental change in the nature and requirements of warfare. As detailed in *Joint Vision 2010*, the Department of Defense is no longer preparing to fight a conventional ground war on the European continent. The concepts that emerged for future United States' military operations are:

- Information superiority – by this is meant the ability to know the location and intent of all enemy forces while being able to conceal U.S. forces from enemy observation.

- Precision engagement – by this is mean the ability of U.S. forces to deliver massive fires against enemy forces with high-precision any time of day and in any weather.

- Dominant maneuver – by this is meant the ability of U.S. forces to rapidly deploy massive military forces from CONUS and overseas bases upon an outbreak of hostilities. Dominant maneuver also means the ability to more rapidly maneuver those forces in a theater than is possible for an enemy.

The science and technology program for the Department should reflect and respond to these concepts and should guide the Department's investment strategy. In fact, the Task Force used these concepts to recommend new military capabilities the Department of Defense will need in the 21st Century as follows:

- long-range surveillance and identification of concealed targets under foliage, in buildings, and in underground facilities;

- stand-off detection of biological, chemical, nuclear, and high-explosive weapons including mines;

- high-energy density fuels/propellants/explosives for increased mobility;

- low-cost, adverse-weather, precision weapons;
- defensive kinetic-kill and directed-energy systems, together with advanced counter-targeting techniques to maximize the survivability of U.S. forces.

In pursuing these new capabilities, a number of supporting revolutionary technologies are likely to be needed. The following lists some of these technologies:

- biological/chemical technologies for BW/CW defense,
- quantum physics approaches to computation and cryptography,
- MEMS (micro-electromechanical systems) for robots and sensors,
- micro-, mini-, and full-sized robots for remote sensing,
- Nano-technology for computation and sensing devices,
- Intelligent systems for recognition of objects,
- high-energy density fuels, propellants, and explosives.

Having described conceptually new capabilities and some suggested new technologies that the Department should address, the Task Force then examined the current program. The Task Force observed the current science and technology program provides largely incremental improvements in current military systems. With the current planning process, approximately 50% of the Department of Defense science and technology program focuses on short-term (3-5 year) objectives, called Defense Technology Objectives. The remaining 50 percent of the science and technology program funds basic research and supporting or enabling technology. It is out of this 50% that revolutionary ideas must be funded.

In the mid-1990s, the Director, Basic Research, established the Strategic Research Objectives as a small set of significant problems to focus the basic research investment. The Task Force believes this is a positive approach, and should continue. However, its scope is limited with the funding set at about $80 million. The more relevant issue is: How much of the science and technology program should the Department invest in revolutionary capability? Recall the current technology-base program is about $4B and the total science and technology is about $7.5B. The funding for the Strategic Research Objectives is only about 2% of the technology base and 1% of the DoD Science and Technology program.

Ten to twenty years ago, the DoD S&T program addressed a number of revolutionary projects such as the development of radar stealth for a variety of military weapon platforms; the Global Positioning System, airborne radar detection of moving ground targets, laser weapons, etc. The question is what revolutionary developments are incorporated in the S&T program today?

Various industry research leaders indicated that typically about two-thirds of their science and technology efforts support improvements in current products, while the remaining one-third is devoted to revolutionary research aimed at completely new product lines. The Task Force believes that the Department should follow this practice as well and devote one-third of the DoD Science and Technology Program to revolutionary military technology research. This would suggest that at least $2.5B of the current S&T funding be devoted to revolutionary technology. While much of this effort should be focused in DARPA, the Task Force believes that a portion of the Service S&T programs should also be focused on revolutionary technology.

<u>Summary Observations</u>

The observations concerning the topic of high-leverage technology can be summarized as follows:

- A high percentage of the current Defense Science and Technology Program is devoted to incremental improvements in current U.S. military systems. The principal exceptions are portions of the OSD and DARPA S&T programs, which do focus on new directions for defense systems.

- A significantly greater portion of the S&T programs should be focused on new technical directions which could produce revolutionary improvements in future U.S. military capability.

- Allocating as much as one-third of the science and technology program to high-payoff S&T initiatives is needed to sustain long-term U.S. military supremacy. Incremental improvements alone are not sufficient.

VI. SUGGESTIONS AND RECOMMENDATIONS

1. **Deputy Secretary of Defense should not allow the science and technology program funding (6.1, 6.2, and 6.3) to decrease. Increasing the science and technology funding to at least $8 billion is indicated if the long-term technical superiority of U.S. military forces is to be ensured.**

   The capability of U.S. military forces ten to twenty years in the future depends on maintaining a strong DoD Science and Technology program at or above its current level. Civil, domestic, and foreign R&D programs tend to focus on short-term objectives and in any case do not address many important military technologies covered under DoD's Science and Technology program. Industrial experience indicates that the current DoD S&T funding level should be increased to about $8 billion/year to maintain technical supremacy of future U.S. military forces.

2. **Under Secretary of Defense (A&T) and the Services should strengthen the management and relevance of the S&T program by taking the following actions:**

   (a) strengthen DDR&E by expanding his/her responsibility to cover at a minimum 6.1, 6.2, 6.3, 6.4 and 6.5 programs;

   (b) integrate S&T management structure in each Service, following the integrated Office of Naval Research structure and using DARPA-like organizations;

   (c) use DARPA for the majority of revolutionary projects while enhancing the coupling of DARPA technologies to the Services;

   (d) Instruct the Services to focus one-third of their S&T programs on revolutionary Programs;

   (e) fill key S&T management positions in the Services with limited-term (4-6 year), high-quality scientific personnel from the private sector (universities, non-profits, and industry). The current 3.3% of key non-DARPA S&T positions filled from the private sector should be increased to 50% or more by 2002 to match the practice in DARPA.

   The management and direction of DoD's S&T program require greater coherence and improved technology transfer between the 6.1, 6.2 and 6.3

components as well as the later engineering programs (6.4, 6.5, 6.6, etc.). This can best be achieved by making DDR&E responsible for the entire suite of programs through engineering development as was the case in the 1960s.

In addition, in each of the Services, the 6.1, 6.2 and 6.3 programs should be managed as a cohesive whole.

Finally, rotation of the S&T management scientists should be sought in order to bring new ideas to the DoD S&T program. A major part of the revolutionary portion of the S&T program should be placed with DARPA because of its proven research management capabilities.

3. **The Services should staff their scientific and engineering laboratory/center positions by replacing over a five-year period up to 50% of the federal civil-service staff with a combination of: (a) limited-term (4-6 year) scientific and engineering personnel (IPAs) provided by the private sector (from universities, non-profits, and industry); (b) a reinstatement of the 1947 Public Law 313 for high-level S&T management positions. This latter action will require Congressional action.**

While the execution of the DoD S&T program at universities and in other private sector organizations is generally satisfactory, there is general agreement that the S&T program execution in Service laboratories and centers is significantly damaged by the impact of civil-service regulations on the technical staff. The introduction of significant numbers of limited-term, highly qualified scientific/technical personnel from the private sector would greatly improve the capability of the DoD laboratories/centers to execute their contributions to the DoD/Service S&T Program.

4. **OSD and the Services should enhance the productivity of the Service laboratories and centers by organizational and especially physical consolidation.**

Unlike many successful industrial research and development efforts, the executors of the Service S&T Program are often physically and organizationally separated from Service development organizations including defense industries. All available means, including continuing requests for Congressional approval where required, should be used to enhance DoD S&T productivity through organizational and physical consolidation of DoD S&T organizations.

5. **DDR&E should insure that approximately 1/3 of the S&T program elements are devoted to revolutionary technology initiatives. DARPA**

should play a major role in executing these efforts along with the Services. DDR&E should also insure that 6.4 and 6.5 funds are programmed by the Services to implement successful revolutionary S&T programs.

A great deal of the current DoD S&T program is devoted to worthwhile but incremental technological improvements in current military capabilities. However, revolutionary technical improvements are the foundation for future U.S. military superiority as they have been in the past. Focusing 1/3 of the DoD S&T Program and follow-on 6.4 and 6.5 efforts on such revolutionary improvements will help insure continued U.S. military dominance over the long term.

APPENDIX A

THE UNDER SECRETARY OF DEFENSE
3010 DEFENSE PENTAGON
WASHINGTON. D.C. 20301-3010

ACQUISITION AND TECHNOLOGY

MAY 05 1997

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Terms of Reference-Defense Science Board Task Force on the Defense Technology Base of the 21st Century

U.S. military strategy calls for the use of superior technology as one critical enabling component of military strategy; You are requested to establish a Defense Science Board (DSB) Task Force to address the issues involved in assuring that the U.S. has adequate technology base from which to develop sustained military superiority for the 21st century; such a base includes technology developed by DoD. but also access to technology developed elsewhere, as well as an assured stream of scientists and engineers that will develop technology and build military materiel. Many internal and external changes influence DoD's options.

You are to recommend a strategy to assure an appropriate technology base. within that strategy, recommend a proper formula for, or level-of-investment, and the characteristics of an investment program by which DoD can complement that which will be done by other federal agencies, other governments, and industry. Also recommend any desirable changes in the process and procedures for monitoring, accessing, and exploiting the most effective technology. Recommend any desirable changes in the organizations that manage and perform the DoD technology base program.

In developing its findings and recommendations, the Task Force should consider:

- erosion of DoD science and technology budget, as well as reduction of IR&D in both defense and commercial industry,
- change in the balance of DoD reliance on defense-unique and dual-use technology,
- non-DoD technology base investment in military-relevant technologies,
- globalization of science,
- globalization of some industry,
- strategies and procedures to rapidly translate technology in the laboratory to fielded products,

- DOD science and technology planning process,
- any changes in the balance of sciences and technologies on which DoD will rely in the future, and
- assurance of a pipeline of scientists and engineers to satisfy research and acquisition needs.

The study will be sponsored by the Director of Defense Research and Engineering. Mr. Walter E. Morrow, Jr., will serve as the Chairman of the Task Force. Col Al Shaffer, USAF, will serve as the Executive Secretary, and LTC T. Van Horn, USA, will serve as the DSB Secretariat Representative.

The Task Force will be operated in accordance with the provision of P.L. 92-463, the "Federal Advisory Committee Act; and DoD Directive 5105.4, the "DoD Federal Advisory Committee Management Program." It is not anticipated that this Task Force will need to go into any "particular matters" within the meaning of Section 208 of Title 18, U.S. Code, nor will it cause any member to be placed in the position of acting as a procurement official.

Paul Kaminski

Paul G. Kaminski

APPENDIX B

Briefings

S&T Base DSB Task Force

Meeting Dates
DSB S&T for the 21st Century

JUNE 23, 1997: **Standards of Conduct--Legal Issues**, OSD General Counsel; **Defense Science and Technology Program / Defense S&T Planning Process**, Mr. George Singley; **DARPA New Initiative - Major Thrusts**, Dr. Lee Buchanan, *DARPA*; **Joint Vision 2010**, BG Dees (Deputy J-7)

JULY 14, 1997: **National and International Science Indicators**, Ms. Jennifer Bond, *NSF, Director, Science & Engineering Indicators Program;* **National Institute of Health**, Dr. Lana Skirboll, *NIH, Director, Science Policy;* **Defense Macro-Scale View**, Mr. Robert Soule, *Deputy Director, OSD PA&E;* **Department of Energy**, Dr. James Decker, *Deputy Director of Energy Research;* **NASA**, Mr. Gregory Reck, *Deputy Chief Technologist*

AUG 26, 1997: **Industrial Research Institute**, Mr. Charles Larson, *Executive Director;* **IBM**, Dr. Randy Isaac, *Vice President, Systems Technology & Science;* **3M**, Dr. Donald Janes, *Director, Government R&D Contracts;* **Rockwell Science Center**, Dr. Joseph Longo, *Vice President, Research;* **Dupont**, Dr. Henry Saffer, *Planning Manager, Corporate R&D Planning*

AUG 27, 1997: **Department of Energy, Laboratory Effectiveness Metrics**, Dr. David Goldman, *Senior Science Advisor;* **Resource Allocation Theory**, Dr. Rolf Clark, *Professor of Economics Industrial College of the Armed Forces;* **Bell Labs/Lucent Technology**, Mr. Bob Laudise, *Adjunct Chemical Director*

SEPT 30, 1997: **OSD Comptroller, View on Investment**, Mr. Ron Garant, *Director of Investment;* **Quadrennial Defense Review**, Mr. Andrew Hoehn, *Principal Director of Strategy;* **NEC Research Institute**, Dr. William Gear, *President, NEC Research Institute;* **Lab Management & Vision 21**, Dr. Lance Davis, *Deputy DDR&E, for Laboratory Management;* **Office of Naval Research**, Rear Admiral Paul Gaffney

S&T Base DSB Task Force

Meeting Dates
DSB S&T for the 21st Century

OCT 1, 1997: **Office of Secretary of Air Force**, Dr. Helmut Hellwig, *Deputy Assistant Secretary, Science, Technology & Engineering;* **Office of the Assistant Secretary of the Army**, Dr. A Fenner Milton, *Deputy Assistant Secretary for Research and Technology;* **Historical DDR&E**, Dr. John Foster, *Consultant;* **Defense Science and Technology**, Mr. George Singley, *Acting Director, Defense Research & Engineering;* **Raytheon Electronic Systems**, Mr. Robert M. Stein, *Vice President and Manager, Advanced Systems*

OCT 29, 1997: **1996 DSB Summer Study, Tactics & Technology for the21st Century**, Mr. Don Latham, *Lockheed Martin;* **Ground Maneuver Net Assessment**, Mr. Mike Lancaster, *SAIC;* **Global Threat Briefing**, Lt. General Hughes, *Director DIA;* **Army After Next**, Colonel Mike Starrey, *TRADOC*

OCT 30, 1997: **Precision Force Net Assessment**, Mr. Jim Hazelett, *SAIC;* **Air Force Long Range Plans**, Dr. Clark Murdock, *Deputy Strategic Plans;* **CIA**, Mr. Russ Dressell, *Office of R&D, CIA*

NOV 18, 1997: **DARPA Views**, Mr. Larry Lynn, *Director, DARPA;* **A Business Practice View**, Mr. Paul Kennedy, *Councilor of Defense, Science & Equipment, United Kingdom MOD;* **National Science Board Outbrief**, Professor Richard Zare, *National Science Board;* **Streamlined Technology Transition**, Dr. James Carlson, *Director for Technical Operations, BMDO*

NOV 19, 1997: **Boeing**, Dr. Frederick Fath, *Vice President Technology, Boeing Information Services, Inc.;* **Navy Technology Transition**, CAPT Manvel, *Program Manager, CVX &* CAPT Burgess, *Program Manager, New Attack Sub;* **Air Force Technology Transition**, Lt Col Chuck Fellow, *ASC, Small Smart Bomb &* Lt Col John Haynes, *PEM, Airborn Laser;* **Technology Insertion Process**, Colonel Carl Hoffman, *Space & Missile Defense Command, US ARMY*

Meeting Dates
DSB S&T for the 21st Century

DEC 16, 1997: **Merck, Inc. R&D Management,** Dr. Linda Distlerath, *Executive Director Public Policy and MRC Public Affairs,Merck, Inc.;* **Technology Transition,** Colonel Jay Johnson, *Acting Deputy PEO for Ground Combat & Support Systems;* **Technology Transition**, Colonel Christopher Cardine, *Project Manager Abrams;* **Navy Laboratory Management and Personnel**, Dr. Timothy Coffey, *Director of Research, NRL*

DEC 17, 1997: **Army Laboratory Management and Personnel,** Dr. John W. Lyons, *Director, Army Research Laboratory;* **Lockheed Martin,** Dr. William Ballhaus, *Corporate Vice President, Science and Engineering, Lockheed Martin;* **Anytime, Anywhere - Navy for the Future,** CAPT Ed Smith, *CNO Executive's Panel*

JAN 21, 1998: **Recap of the ARES Meeting,** Dr. Jasper Lupo, *Director, Sensors, Electronics & Battlespace Environment;* **Information Centric Warfare,** VADM Arthur K. Cebrowski, *Director, Space, Information Warfare, Command Control (N6);* **"The Road to 2015"**, Mr. John Peterson, *President, Arlington Institute;* **Defense Strategic Research Objectives,** Dr. Bob Trew, *Director, Basic Research*

JAN 22, 1998: **UltraScale Computing,** Mr. E.D. Maynard, Jr., *Program Manager, Information Technology Office, DARPA;* **Air Force Research Management**, Dr. Donald C. Daniel, *Executive Director & Chief Scientist, Air Force Research Laboratory*

APPENDIX C
A Mathematical Approach to Determining DoD Science and Technology Investments

INTRODUCTION

It is possible to formulate a mathematical approach to determine the optimum fraction of total DoD funding that should be applied to funding of its science and technology programs. As will be seen, while it is possible to structure a workable formulation, it is very difficult at this time to establish the correct coefficients to use in the formulation. In spite of that limitation, this formulation may be of use at some point in the future when these coefficients can be established, at least in an approximate form.

BASIC FORMULATI0N

The starting point for the formulation consists of the two equations shown in Fig. C-1 below. The first equation sets a bound on the total DoD expenditures in any one year which is equal to the sum of the funds for a number of DoD/Service functions which support its ability to project military power. Some of these, such as logistic support cover current operations. Others such as the Technology Base and Demonstration programs impact capabilities a number of years in the future. These latter two areas comprise in total the Science and Technology Program of the Department, the subject of this study.

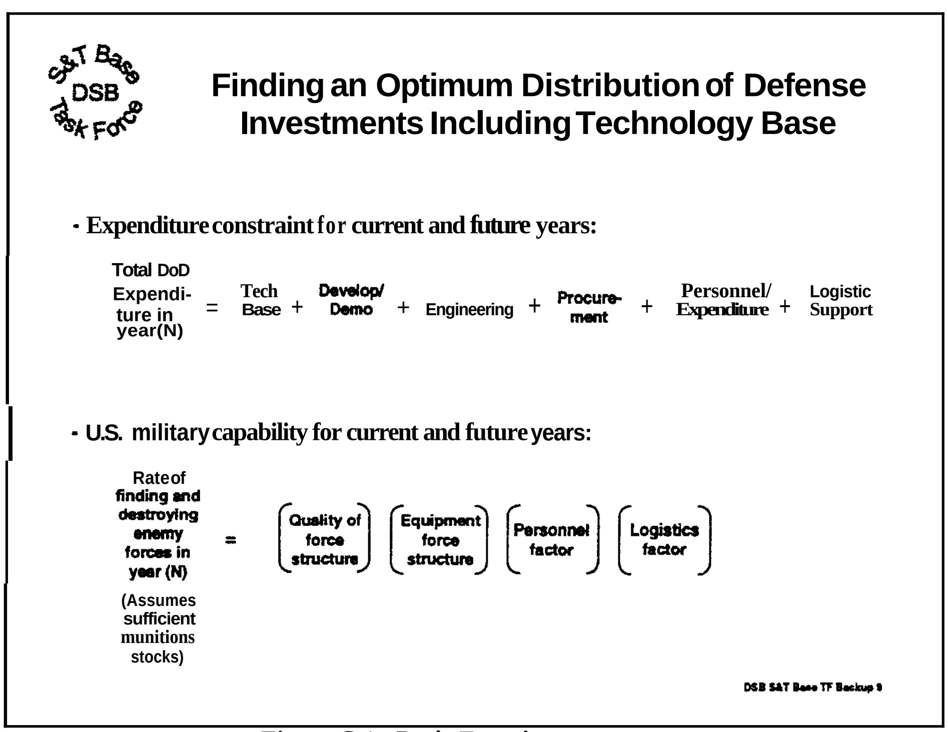

Figure C-1: Basic Equations

The other equation, in a very general way, relates the various components of military capability to the ability of the forces to destroy potential enemy forces in terms of a kill rate. This assumes, of course, that munitions stocks are unlimited. If such is not the case, a reformulation can be used in which the capability is related to the total number of enemy elements that can be destroyed.

The second equation can be quantified in terms of a number of parameters as shown in Fig. C-2.

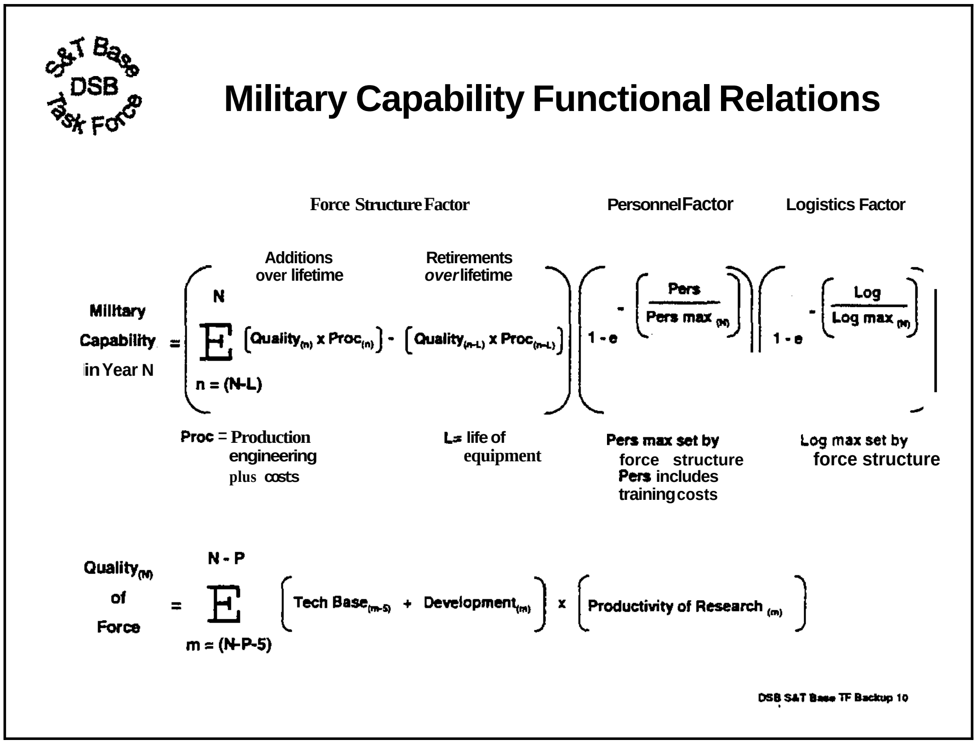

Figure C-2: Expansion of Military Capability Equation

<u>DETAILED EQUATIONS</u>

Figure C-2 breaks the second equation into **two** parts, the first relating to the overall capability at a given year in the future (N). The second part develops a formulation for the quality of the force structure at a year (N) in the future. In this equation P is the number of years required for the engineering and production of the equipment demonstrated under the Science and Technology Program.

The first equation in this figure evaluates military capability as the product of the quantity and quality of the force structure, military personnel strength and logistics support. The force-structure component is augmented by current and past procurement and is depreciated as equipment reaches the end of its life.

MAXIMIZATION PROCESS

Figure C-3 shows the process of optimization. After the total cost constraint is introduced into the capability equation for each year over the next few decades, a set of differential equations can be derived for each year which involve taking the partial derivatives with respect to each class of funding (S&T, engineering and procurement, personnel, logistics, etc.). Each of these differentials is then set equal to zero to produce a set of simultaneous equations for each year in the future and in each year for the separate classes of funding.

S&T Base DSB Task Force

Maximization of Long-Term Military Capability With an Expenditure Constraint

- Substitute cost constraint into the military capability relations for each future year of interest (perhaps up to 25 years)
- Take the partial derivatives of the military capabilities relations for each year with respect to the expenditure categories and setting them equal to zero, ie.

$$\left.\begin{aligned} &\frac{d(\text{military capability, yr=n})}{d(\text{tech base expenditures})} = 0 \\ &\frac{d(\text{military capability, yr=n})}{d(\text{devel/demo expenditures})} = 0 \end{aligned}\right\} \text{For year n = 0 to 25}$$

. etc

- Solve the resulting set of several simultaneous equations to get:

Ontimum Expenditures for: Tech Base, Development/Demonstration, Engineering Procurement, Personnel, Logistics — For each year up to 25 in the future

- CAVEAT The functions relating military capabilities to expenditures are very poorly understood

DSB S&T Base TF Backup 11

Figure C-3: Maximization Process

The equations are then solved for the optimum distribution of funding for each year involved. Since the equations are likely to be non-linear, the standard-matrix algebra-solution approach will probably not be applicable. Instead, an iterative optimization is a more appropriate approach to a solution. A useful starting point for use an iterative approach would be to use the current funding structure.

ISSUES

The most significant problem in using this approach to determine optimum funding of DoD programs is the determination of the coefficients to be used in the equations.

Another problem is that of getting agreement on the proper parameter to evaluate military capability. Depending on the nature *of* the contingency to be faced, different measures of military capability will probably be appropriate.

Finally, there is the matter of division of funding among the Services. Here again, the nature of the contingencies will be all-important. Most probably, a mixture of possible contingencies will have to be used to get useful results.

APPENDIX D
Intergovernmental Personnel Act of 1970

INTERGOVERNMENTAL PERSONNEL ACT OF 1970

For Legislative History of Act, see p. 5879

PUBLIC LAW 91-648; 84 STAT. 1909

[S. 11]

An Act to reinforce the federal system by strengthening the personnel resources of State and local governments, to improve intergovernmental cooperation in the administration of grant-in-aid programs, to provide grants for improvement of State and local personnel administration, to authorize Federal assistance in training State and local employees, to provide grants to State and local governments for training of their employees, to authorize interstate compacts for personnel and training activities, to facilitate the temporary assignment of personnel between the Federal Government, and State and local governments, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That:

This Act may be cited as the "Intergovernmental Personnel Act of 1970".

TITLE IV—MOBILITY OF FEDERAL, STATE, AND LOCAL EMPLOYEES

DECLARATION OF PURPOSE

Sec. 401. The purpose of this title is to provide for the temporary assignment of personnel between the Federal Government and State and local governments and institutions of higher education.

AMENDMENTS TO TITLE 5, UNITED STATES CODE

Sec. 402. (a) Chapter 33 of title 5, United States Code,[39] is amended by inserting the following new subchapter at the end thereof:

"SUBCHAPTER VI—ASSIGNMENTS TO AND FROM STATES

"§ 3371. Definitions

"For the purpose of this subchapter—

"(1) 'State' means—

"(A) a State of the United States, the District of Columbia, the Commonwealth of Puerto Rico, and a territory or possession of the United States; and

"(B) an instrumentality or authority of a State or States as defined in subparagraph (A) of this paragraph (1) and a Federal-State authority or instrumentality; and

"(2) 'local government' means—

"(A) any political subdivision, instrumentality, or authority of a State or States as defined in subparagraph (A) of paragraph (1); and

"(B) any general or special purpose agency of such a political subdivision, instrumentality, or authority.

"§ 3372. General provisions

"(a) On request from or with the concurrence of a State or local government, and with the consent of the employee concerned, the head of an executive agency may arrange for the assignment of—

"(1) an employee of his agency to a State or local government; and

39. 5 U.S.C.A. §§ 3371 to 3376.

"(2) an employee of a State or local government to his agency;

for work of mutual concern to his agency and the State or local government that he determines will be beneficial to both. The period of an assignment under this subchapter may not exceed two years. However, the head of an executive agency may extend the period of assignment for not more than two additional years.

"(b) This subchapter is authority for and applies to the assignment of—

"(1) an employee of an executive agency to an institution of higher education; and

"(2) an employee of an institution of higher education to an executive agency.

"§ 3373. **Assignment of employees to State and local governments**

"(a) An employee of an executive agency assigned to a State or local government under this subchapter is deemed, during the assignment, to be either—

"(1) on detail to a regular work assignment in his agency; or

"(2) on leave without pay from his position in the agency.

An employee assigned either on detail or on leave without pay remains an employee of his agency. The Federal Tort Claims Act and any other Federal tort liability statute apply to an employee so assigned. The supervision of the duties of an employee on detail may be governed by agreement between the executive agency and the State or local government concerned.

"(b) The assignment of an employee of an executive agency either on detail or on leave without pay to a State or local government under this subchapter may be made with or without reimbursement by the State or local government for the travel and transportation expenses to or from the place of assignment and for the pay, or supplemental pay, or a part thereof, of the employee during assignment. Any reimbursements shall be credited to the appropriation of the executive agency used for paying the travel and transportation expenses or pay.

"(c) For any employee so assigned and on leave without pay—

"(1) if the rate of pay for his employment by the State or local government is less than the rate of pay he would have received had he continued in his regular assignment in the agency, he is entitled to receive supplemental pay from the agency in an amount equal to the difference between the State or local government rate and the agency rate;

"(2) he is entitled to annual and sick leave to the same extent as if he had continued in his regular assignment in the agency; and

"(3) he is entitled, notwithstanding other statutes—

"(A) to continuation of his insurance under chapter 87 of this title, and coverage under chapter 89 of this title or

other applicable authority, so long as he pays currently into the Employee's Life Insurance Fund and the Employee's Health Benefits Fund or other applicable health benefits system (through his employing agency) the amount of the employee contributions;

"(B) to credit the period of his assignment under this subchapter toward periodic step-increases, retention, and leave accrual purposes, and, on payment into the Civil Service Retirement and Disability Fund or other applicable retirement system of the percentage of his State or local government pay, and of his supplemental pay, if any, that would have been deducted from a like agency pay for the period of the assignment and payment by the executive agency into the fund or system of the amount that would have been payable by the agency during the period of the assignment with respect to a like agency pay, to treat his service during that period as service of the type performed in the agency immediately before his assignment; and

"(C) for the purpose of subchapter I of chapter 85 of this title, to credit the service performed during the period of his assignment under this subchapter as Federal service, and to consider his State or local government pay (and his supplemental pay, if any) as Federal wages. To the extent that the service could also be the basis for entitlement to unemployment compensation under a State law, the employee may elect to claim unemployment compensation on the basis of the service under either the State law or subchapter I of chapter 85 of this title.

However, an employee or his beneficiary may not receive benefits referred to in subparagraphs (A) and (B) of this paragraph (3), based on service during an assignment under this subchapter for which the employee or, if he dies without making such an election, his beneficiary elects to receive benefits, under any State or local government retirement or insurance law or program, which the Civil Service Commission determines to be similar. The executive agency shall deposit currently in the Employee's Life Insurance Fund, the Employee's Health Benefits Fund or other applicable health benefits system, respectively, the amount of the Government's contributions on account of service with respect to which employee contributions are collected as provided in subparagraphs (A) and (B) of this paragraph (3).

"(d) (1) An employee so assigned and on leave without pay who dies or suffers disability as a result of personal injury sustained while in the performance of his duty during an assignment under this subchapter shall be treated, for the purpose of subchapter I of chapter 81 of this title, as though he were an employee as defined by section 8101 of this title who had sustained the injury in the performance of duty. When an employee (or his dependents in case of death) entitled by reason of injury or death to benefits under

subchapter I of chapter 81 of this title is also entitled to benefits from a State or local government for the same injury or death, he (or his dependents in case of death) shall elect which benefits he will receive. The election shall be made within one year after the injury or death, or such further time as the Secretary of Labor may allow for reasonable cause shown. When made, the election is irrevocable unless otherwise provided by law.

"(2) An employee who elects to receive benefits from a State or local government may not receive an annuity under subchapter III of chapter 83 of this title and benefits from the State or local government for injury or disability to himself covering the same period of time. This provision does not—

"(A) bar the right of a claimant to the greater benefit conferred by either the State or local government or subchapter III of chapter 83 of this title for any part of the same period of time;

"(B) deny to an employee an annuity accruing to him under subchapter III of chapter 83 of this title on account of service performed by him; or

"(C) deny any concurrent benefit to him from the State or local government on account of the death of another individual.

"§ 3374. **Assignments of employees from State or local governments**

"(a) An employee of a State or local government who is assigned to an executive agency under an arrangement under this subchapter may—

"(1) be appointed in the executive agency without regard to the provisions of this title governing appointment in the competitive service for the agreed period of the assignment; or

"(2) be deemed on detail to the executive agency.

"(b) An employee given an appointment is entitled to pay in accordance with chapter 51 and subchapter III of chapter 53 of this title or other applicable law, and is deemed an employee of the executive agency for all purposes except—

"(1) subchapter III of chapter 83 of this title or other applicable retirement system;

"(2) chapter 87 of this title; and

"(3) chapter 89 of this title or other applicable health benefits system unless his appointment results in the loss of coverage in a group health benefits plan the premium of which has been paid in whole or in part by a State or local government contribution.

"(c) During the period of assignment, a State or local government employee on detail to an executive agency—

"(1) is not entitled to pay from the agency;

"(2) is deemed an employee of the agency for the purpose of chapter 73 of this title, sections 203, 205, 207, 208, 209, 602, 603, 606, 607, 643, 654, 1905, and 1913 of title 18, section 638a of title 31, and the Federal Tort Claims Act and any other Federal tort liability statute; and

"(3) is subject to such regulations as the President may prescribe.

The supervision of the duties of such an employee may be governed by agreement between the executive agency and the State or local government concerned. A detail of a State or local government employee to an executive agency may be made with or without reimbursement by the executive agency for the pay, or a part thereof, of the employee during the period of assignment.

"(d) A State or local government employee who is given an appointment in an executive agency for the period of the assignment or who is on detail to an executive agency and who suffers disability or dies as a result of personal injury sustained while in the performance of his duty during the assignment shall be treated, for the purpose of subchapter I of chapter 81 of this title, as though he were an employee as defined by section 8101 of this title who had sustained the injury in the performance of duty. When an employee (or his dependents in case of death) entitled by reason of injury or death to benefits under subchapter I of chapter 81 of this title is also entitled to benefits from a State or local government for the same injury or death, he (or his dependents in case of death) shall elect which benefits he will receive. The election shall be made within 1 year after the injury or death, or such further time as the Secretary of Labor may allow for reasonable cause shown. When made, the election is irrevocable unless otherwise provided by law.

"(e) If a State or local government fails to continue the employer's contribution to State or local government retirement, life insurance, and health benefit plans for a State or local government employee who is given an appointment in an executive agency, the employer's contributions covering the State or local government employee's period of assignment, or any part thereof, may be made from the appropriations of the executive agency concerned.

"§ 3375. **Travel expenses**

"(a) Appropriations of an executive agency are available to pay, or reimburse, a Federal or State or local government employee in accordance with—

"(1) subchapter I of chapter 57 of this title, for the expenses of—

"(A) travel, including a per diem allowance, to and from the assignment location;

"(B) a per diem allowance at the assignment location during the period of the assignment; and

"(C) travel, including a per diem allowance, while traveling on official business away from his designated post of duty during the assignment when the head of the executive agency considers the travel in the interest of the United States;

"(2) section 5724 of this title, for the expenses of transportation of his immediate family and of his household goods and personal effects to and from the assignment location;

"(3) section 5724a(a) (1) of this title, for the expenses of per diem allowances for the immediate family of the employee to and from the assignment location;

"(4) section 5724a(a) (3) of this title, for subsistence expenses of the employee and his immediate family while occupying temporary quarters at the assignment location and on return to his former post of duty; and

"(5) section 5726(c) of this title, for the expenses of nontemporary storage of household goods and personal effects in connection with assignment at an isolated location.

"(b) Expenses specified in subsection (a) of this section, other than those in paragraph (1) (C), may not be allowed in connection with the assignment of a Federal or State or local government employee under this subchapter, unless and until the employee agrees in writing to complete the entire period of his assignment or one year, whichever is shorter, unless separated or reassigned for reasons beyond his control that are acceptable to the executive agency concerned. If the employee violates the agreement, the money spent by the United States for these expenses is recoverable from the employee as a debt due the United States. The head of the executive agency concerned may waive in whole or in part a right of recovery under this subsection with respect to a State or local government employee on assignment with the agency.

"(c) Appropriations of an executive agency are available to pay expenses under section 5742 of this title with respect to a Federal or State or local government employee assigned under this subchapter.

"§ 3376. Regulations

"The President may prescribe regulations for the administration of this subchapter."

(b) The analysis of chapter 33 of title 5, United States Code, is amended by inserting the following at the end thereof:

"SUBCHAPTER VI—ASSIGNMENTS TO AND FROM STATES

"Sec.
"3371. Definitions.
"3372. General provisions.
"3373. Assignments of employees to State or local governments.
"3374. Assignments of employees from State or local governments.
"3375. Travel expenses.
"3376. Regulations."

REPEAL OF SPECIAL AUTHORITIES

Sec. 403. The Act of August 2, 1956, as amended (7 U.S.C. 1881–1888),[40] section 553 of the Act of April 11, 1965 as amended (20 U.S.C. 867),[41] and section 314(f) of the Public Health Service Act (42 U.S.C. 246(f)) (less applicability to commissioned officers of the Public Health Service) [42] are hereby repealed.

40. 7 U.S.C.A. §§ 1881 to 1888.
41. 20 U.S.C.A. § 867.
42. 42 U.S.C.A. § 246(f).

APPENDIX E
Public Law 313 (from 1947)

WAR AND NAVY DEPARTMENTS-PROFESSIONAL
AND SC IENTIFIC SERVICE

See Congressional Comment, P. 1533

LAW 313

[H.R. 4 0841

An Act to authorize the creation of additional positions in the professional and scientific service in the War and Navy Departments.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That:

The Secretary of War is authorized to establish and fix the compensation for, within the War Department, not more than thirty positions, and the Secretary of the Navy is authorized to establish and fix the compensation for, within the Naval Establishment, not more than fifteen positions in the professional and scientific service, each such position being established to effectuate those research and development functions, relating to the national defense, military and naval medicine, and any and all other activities of the War Department or Naval Establishment which require the services of specially qualified scientific or professional personnel: Provided, That the rates of compensation for positions established pursuant to the provisions of this Act shall not be less than $10, 000 per annuni nor more than $15,000 per annum, and shall be subject to the approval of the Civil Service Commission.

See. 2 Positions created pursuant to this Act shall be included in the classified civil service of the United States, but appointments to such positions shall be made without competitive examination upon approval of the proposed appointee's qualifications by the Civil Service Commission or such officers or agents as it may designate for this purpose.

See. 3. The Secretary of War and the Secretary of the Navy, respectively, shall submit to the Congress, not later than December 31 of each year, a report setting forth the number of Positions established pursuant to this Act in their respective departments during that calendar year, and the name, rate of compensation, and description of the qualifications of each incumbent, together with a statement of the functions performed by each. In any instance where the Secretary of War or the Secretary of the Navy may consider full public report of these items detrimental to the national security, he is authorized to omit such items from his annual report and, in lieu thereof, to present such information in executive sessions of such committees of the Senate and House of Representatives as the presiding officers of those bodies shall designate.

Approved August 1,1947.